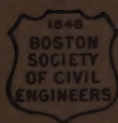


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CIVIL ENGINEERS



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BOSTON SOCIETY OF CIVIL ENGINEERSFOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"Construction of a Pre-Cast Concrete Slab Bridge at Central St., Lowell." By S. Stanley Kent.

"Strengthening Old Bridges." By Lewis E. Moore.

"A Long Span Reinforced Concrete Girder Bridge at Cohasset Narrows." By B. A. Rich.

"Mosquito Control in Massachusetts." By George C. Whipple.

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MINUTES OF MEETING.

BOSTON, October 18, 1922. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.45 P. M., by the President, Professor Dugald C. Jackson. There were 110 members and guests present.

The minutes of the meeting of September 20 were approved as printed in the September JOURNAL.

The Secretary reported for the Board of Government the names of those elected to membership: Herbert A. Sweet, grade of Member; Samuel T. Drew, grade of Junior.

The President announced the death of William F. Morse on September 15. It was voted that a committee of two be appointed by the President to prepare a memoir of Mr. Morse.

The President announced the death of Hon. John N. Cole, Commissioner of Public Works. Although not a member of the Society, Mr. Cole presented an interesting paper on Massachusetts Highways at a meeting on February 28, 1922.

It was voted unanimously that the Board of Government be authorized to use the income from the Permanent Fund for the current year to such an extent as they deem necessary in payment of the current expenses of the Society. This vote had been passed at the September meeting and in accordance with the By-Laws an affirmative vote of two-thirds at two successive regular meetings is required to make an appropriation from the Permanent Fund.

The first meeting of The Affiliated Technical Societies of Boston is to be held Thursday, November 23, 1922, on the subject of "Commercial Aviation — The Present State of the Art — with Special Reference to the Development of Boston as an Air Port." It was voted that the Society omit the regular November meeting in order to promote greater interest and attendance at the Affiliation meeting on November 23.

Professor Jackson announced that Frank A. Barbour, President of The New England Water Works Association, had extended a cordial invitation to the members of the BOSTON SOCIETY OF CIVIL ENGINEERS to attend a luncheon meeting of that society at the City Club on Tuesday, November 14. The program, which will be of unusual interest, is as follows: "Some Engineering Aspects of Cast Iron" by Dr. Richard Moldenke, Watchung, N. J.; "Tars, New and Old" by S. R. Church, Chemist and Manager of Oil and Tar Division, The Barrett Company, New York, N. Y., and moving pictures of the Centrifugal Process of Casting Pipe taken at the new plant of the United States Cast Iron Pipe & Foundry Co., Birmingham, Ala.

The program of the meeting was a "Symposium on Bridges," and the first paper presented was "Construction of a Pre-Cast Slab Bridge at Central Street, Lowell," by S. Stanley Kent, Assistant Engineer, Proprietors of Locks and Canals, Lowell, Mass.

Lewis E. Moore, Consulting Engineer, Boston, formerly connected with the Department of Public Utilities of Massachusetts, discussed the topic "Strengthening of Old Bridges." A paper entitled, "A Long Span Reinforced Concrete Girder Bridge at Cohasset Narrows," was presented by Barzillai A. Rich, of Fay, Spofford & Thorndike, Consulting Engineers, Boston.

The original program included "A Survey of Massachusetts Bridges" by W. F. Williams, Bridge Engineer, Department of Public Works, but on account of the death of Hon. John N. Cole, Commissioner of Public Works, on the day of the meeting, Mr. Williams did not present the paper at this time.

After an interesting discussion of these papers, all of which were illustrated by slides, the meeting adjourned at 10.15 P.M.

J. B. BABCOCK, *Secretary*.

APPLICATIONS FOR MEMBERSHIP.

[November 23, 1922.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

ALCOTT, WILLIAM JEFFERSON, Jr., Watertown, Mass. (Age 28, b. Chelsea, Mass.) Attended Mass. Agricultural College two years. From August 1915-January 1916 was a transitman with the Rhode Island Co. of Providence, R. I.; from January 1916 to June 1917 was a rodman with N. Y., N. H. & H. R. R. at New London, Conn.; with the 101st Engineers from June 1917 to May 1919; from June 1919 to September, same year, was inspector on the N. Y., N. H., & H. R. R., also from June 1920 to September of same year; entered Tufts College in the fall of 1919 and graduated in 1922 with B.S. in civil engineering; during the summers of 1921 and 1922 was assistant engineer in the Massachusetts Highway Commission, and in November 1922 became draftsman on the B. & M. R. R. where he is at present employed. Refers to H. C. Archibald, B. W. Guppy, P. Jones and F. C. Shepherd.

ARMINGTON, EVERETT ALLAN, Everett, Mass. (Age 29, b. Weymouth, Mass.) From 1910 to 1918 engaged in highway engineering with the Massachusetts Highway Commission; 1918-1919 draftsman with the B. & A. R. R.; 1919-1920 draftsman and designer with Stone & Webster, Inc.; 1921-1922 cost work with the B. & M. R. R.; and at present structural draftsman with B. & M. R. R. Graduate of High School, and two years at Northeastern University, also took correspondence courses with Massachusetts Board of Education and University of Michigan. Refers to H. C. Archibald, L. G. Brackett, P. Jones and F. C. Shepherd.

BAKER, RALPH EDMUND, Medford, Mass. (Age 34, b. Joliet, Ill.) Graduate of the Manchester High School and of Dartmouth College, also of Thayer School of Civil Engineering. From 1913-1914 was assistant resident engineer with French & Hubbard; from February, 1914-October, same year, detailing reinforced steel; from October, 1914-March, 1916 with B. & M. R. R. as bridge and building inspector under B. W. Guppy; 1916-1917 engineering draftsman, designing five story reinforced factory building, and other large buildings; 1918 assisted in supervising and inspecting a large factory plant in Erie, Pa.; September, 1918-July, 1922 was employed at the U. S. Naval Ordnance Plant, S. Charleston, W. Va., as engineering draftsman; from September 1922 to date with F. O. Lewis as engineer on proposed new office building. Refers to B. W. Guppy, H. S. Knowlton, W. D. Trask, R. E. Whitney, R. Whitman and J. F. Wilber.

BARTLETT, JOSEPH H. Jr., Quincy, Mass. (Age 18, b. Brooklyn, N.Y.) Graduate of Quincy High School 1920. Is now a Junior at Northeastern University. Was a rodman with Ernest W. Branch for seven weeks and with Aspinwall & Lincoln to date. Refers to H. B. Alvord, E. W. Branch, C. S. Ell, J. W. Ingalls, E. H. Lincoln and G. H. Newcomb.

BROWN, HOWARD LESLIE, Medford, Mass. (Age 26, b. Brockton, Mass.) Graduate of Wentworth Institute, architectural construction and engineering course; Franklin Union evening school one winter, also took course in surveying at Tufts College. Employed by Boston & Maine R. R. in office of Engineer of Structures from May 1919 to the present time. Refers to H. C. Archibald, B. W. Guppy, P. Jones, A. W. Knowlton, D. N. Peasley.

BURKE, JOHN JOSEPH, Boston, Mass. (Age 34, b. Boston, Mass.) Graduate of Mechanic Arts High School, also attended Franklin Union evening classes 1915-1917. From 1907-1910 was a rodman; 1910-1914 was a transitman; 1915 to the present time has been in charge of engineering party in Sewer Department, City of Boston. Refers to F. J. Gately, G. W. Hamilton, W. A. Johnson and J. E. L. Monaghan.

BURROUGHS, JOHN HENRY, Dorchester, Mass. (Age 49, b. Bridgeport, Conn.) Educated in the Boston public schools and English High. Started engineering with Charles F. Baxter, in 1895 and with the City of Boston 1896; Has been in the Street Commissioner's Department, Surveying Division from 1896 to the present time. Is now assistant engineer in Street Laying Out Department. Refers to N. J. Holland, H. C. Mildram, J. E. L. Monaghan, L. J. Monahan and E. H. Rogers.

CADIGAN, DANIEL J., Boston, Mass. (Age 40, b. Boston, Mass.) Educated in the Boston schools. Became rodman for City of Boston from 1910-1917; transitman 1917-1922 with the City where he is at the present time. Refers to J. E. Brosnahan, G. W. Dakin, E. S. Dorr, C. S. Drake, F. A. Garvin and J. E. L. Monaghan.

CARROLL, CHARLES CHRISTIAN, Boston, Mass. (Age 53, b. Boston, Mass.) Educated in the public schools of Boston, Ottawa University of Canada and Lowell Institute Course 1906-1908. Was rodman and then transitman for City of Boston 1887-1898; draftsman 1898-1906; draftsman with State of Massachusetts 1906-1908; assistant engineer, City of Boston, 1908-1920; chief engineer, Universal Tide Power Co., 1920-1922; and at present is draftsman and engineering inspector in the Sewer Service, City of Boston. Refers to G. W. Dakin, E. S. Dorr, F. A. Lovejoy, D. J. Lynch and J. E. L. Monaghan.

CARROLL, WILLIAM N., Dorchester, Mass. (Age 42, b. Boston, Mass.) Educated in the Boston schools. Worked with Metropolitan Park Commission as rodman 1897-1900; as transitman with City of Boston, 1900-1907; assistant engineer, City of Boston, 1907-1922; is at present assistant in the Street Laying Out Department. Refers to A. J. Howland, H. C. Mildram, J. E. L. Monaghan, L. J. Monahan and F. O. Whitney.

CHUBBUCK, HIRAM R., Dorchester, Mass. (Age 53, b. Roxbury, Mass.) He has been employed in the Highway Department since 1891 and at present is assistant engineer in the Highway Division of Public Works Department, City of Boston. Refers to B. F. Bates, J. E. Carty, M. T. Cook, C. S. Drake A. E. Haskell and F. P. Spalding.

COHEN, SAMPSON KALMON, Roxbury, Mass. (Age 34, b. Poland.) Educated in the public schools of Boston and a graduate of Mass. Inst. Tech. in 1910. From 1910-1911 he was a tracer and detailer with a bridge company; 1911-1913 a checker of shop drawings; 1913-1914 a structural draftsman on the Isthmian Canal; 1914-1916 chief draftsman, Bridge Division, Missouri Pacific R. R.; 1916-1917 chief bridge designer B. & M. R.R.; 1917-1919 with the 101st Engineers; 1919 to the present employed in the office of Engineer of Structures B. & M. R. R. Refers to H. C. Archibald, B. W. Guppy, P. Jones and C. M. Spofford.

DONNELLY, WILLIAM FRANCIS, Boston, Mass. (Age 28, b. Boston.) A graduate of Wentworth Institute. From 1914-1917 he was employed on Water Service, City of Boston, as a rodman; 1917 to date was transitman in the same service. Refers to C. J. Carven, F. A. McInnes, J. McNulty, J. E. L. Monaghan, D. J. Sullivan and F. I. Winslow.

FITZGERALD, THOMAS J., Boston, Mass. (Age 42, b. Boston, Mass.) He entered the employ of the City of Boston after graduating from the Boston English High School. He began work with the Engineering Department of the City of Boston; also served in the Bridge Division until 1922 when he was transferred to the Highway. Refers to J. E. Carty, M. T. Cook, R. N. Cutter, B. F. Bates, E. H. Howe and F. P. Spalding.

FLYNN, LAWRENCE R., Boston, Mass. (Age 54, b. Ireland). Was educated in Ireland. Was principal teacher of mathematics in the Dublin Model School 1894-1902; held the same position in the Boardman Advanced Evening School in New Haven, Conn., 1903-1911 inclusive; was private secretary to assistant treasurer to the Comptroller of State of Connecticut 1912-1915; with the City of Boston since August 1916 as rodman, provisional draftsman and instrumentman, and now in the Sewer Service. Refers to T. F. Bowes, G. W. Dakin, E. S. Dorr, C. S. Drake, F. S. Lovejoy, and J. E. L. Monaghan.

GARNEY, EMERY W., Bridgewater, Mass. (Age 21, b. Bridgewater, Mass.) Graduated from the Bridgewater High School and then spent two years at Northeastern University during which time he has spent about forty-six weeks in school and fifty weeks at engineering practice; has had experience as rodman, transitman, timekeeper, and is now beginning his junior year at Northeastern University. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls and W. E. Nightingale.

HOISINGTON, EDWIN T., West Roxbury, Mass. (Age 50, b. Hartland, Vt.) Had three years at Mass. Inst. Tech. He was with the City of Boston as rodman and instrumentman and assistant engineer up to date. Refers to B. F. Bates, F. H. Fay, A. E. Haskell, A. Howland, J. E. L. Monaghan and J. H. Sullivan.

HUNT, ARTHUR WILLIAM, Boston, Mass. (Age 47, b. Boston, Mass.) Educated in the Boston public schools and English High. Was a rodman in the City Engineer's office 1891-1892; rodman with the Old Colony 1893; rodman and transitman with City Engineer, Boston, 1894-1898; transitman and draftsman 1898-1911; draftsman and assistant engineer, Highway Division, Public Works Department, City of Boston, 1911-1916; and assistant engineer in the same department, in charge of field party on street construction from 1916 to date. Refers to B. F. Bates, F. H. Fay, A. E. Haskell, J. E. L. Monaghan, C. G. Norris and J. H. Sullivan.

KELLY, THOMAS, Jamaica Plain, Mass. (Age 31, b. Roxbury, Mass.) He was a rodman in the Sewer Service, City of Boston, 1911-1916; since this time he has been transitman in the same department. Refers to J. E. Carty, E. S. Dorr, C. S. Drake, W. V. P. Hoar, D. P. Kelley and J. E. L. Monaghan.

KENNEY, THOMAS B., Boston, Mass. (Age 33, b. Boston.) Educated in the Boston schools; graduate of Northeastern University in civil engineering. From 1911-1912 was rodman in Sewer Service; 1912-1917 transitman and in charge of party; 1917-1921 transitman in Street Laying Out Department; a part of 1921 assistant engineer in the Highway Division, Public Works Department of Mass.; since which time he has been in the Street Laying Out Department as transitman and at the present time is engineer for the Assessing Department of City of Boston. Refers to T. F. Bowes, C. S. Drake, W. E. Hannan, D. P. Kelley, J. E. L. Monaghan, and F. O. Whitney.

LENNON, ARTHUR J., Boston, Mass. (Age 34, b. Boston.) Educated in the public schools of Boston. Two years at Mass. Inst. Tech., chemical engineering course, and two years at Lowell Institute, building course. He was rodman in the sewer service 1910-1912, transitman 1912-1919; and is at the present time employed in the same service. Refers to G. W. Hamilton, W. A. Johnson, J. E. L. Monaghan, E. F. Murphy and L. B. Reilly.

LIDDELL, WILLIAM ANDREW, Lowell, Mass. (Age 28, b. Lowell, Mass.) Graduated from Mass. Inst. Tech. in civil engineering 1916. Returned to the Institute as assistant in civil engineering for the following year. From August 1917-October 1918 with American Tel. & Tel. in New York, with the exception of eight months in the army. In October 1919 returned to Mass. Inst. Tech. as instructor in civil engineering covering surveying, hydraulics and hydraulic problems. During spare time he has been connected with the Locks and Canals of Lowell, with Fay, Spofford & Thorndike and H. K. Barrows, Consulting Engineers, and City Planning Board; and at the present date is still instructor at Technology. Refers to H. K. Barrows, D. Porter, A. T. Safford and C. M. Spofford.

MCCARTY, FRANK P., Roxbury, Mass. (Age 48, b. Roxbury, Mass.) Graduate of Roxbury High School; a law student from 1892-95; His experience has been as follows: rodman 1895-98; transitman from 1898 to the present time; is now in the Laying Out Department as transitman. Refers to N. J. Holland, H. C. Mildram, J. E. L. Monaghan, and F. O. Whitney.

MOFFIE, SAUL E., Winthrop, Mass. (Age 25, b. Boston, Mass.) Attended Franklin Union where he took civil engineering course, also took civil engineering at Tufts College where he received degree B.S. During the summer of 1920 employed by Lockwood, Greene & Co., tracing and detailing; during the summer of 1922 was draftsman with Lamson Co.; and at present is employed as structural draftsman, with the Boston & Maine R. R. Refers to H. C. Archibald, B. W. Guppy, P. Jones and F. C. Shepherd.

MOULTON, EDWARD L., Mattapan, Mass. (Age 55, b. Dorchester, Mass.) Educated in the Boston public schools. He was transitman with Whitman & Breck, 1885-1886; transitman, City Surveyor's office, 1887-1892; assistant engineer in charge of party Street Laying Out Department 1892-1916; assistant engineer in charge of department (Street Laying Out Department.) 1916 to date. Refers to F. M. Miner, H. C. Mildram, F. O. Whitney and C. S. Drake.

MURPHY, FREDERICK FRANCIS, Boston, Mass. (Age 40, b. Boston, Mass.) Educated in the schools of Boston and took a course at Y.M.C.A. He entered City service 1897 as office boy and was promoted, after examination, to the position of rodman and then as senior draftsman and at the present time is designing draftsman in Engineering Division of Street Laying Out Department. Refers to A. Howland, H. C. Mildram, F. M. Miner, H. L. Patterson and F. O. Whitney.

MURRAY, JAMES SAUNDERS, Boston, Mass. (Age 49, b. Boston, Mass.) Educated in the Boston public schools, Y.M.C.A. and International Correspondence School. He entered the employ of the City of Boston as rodman in Street Laying Out Department 1896; was appointed transitman July 1906 and has been in this department ever since. Refers to A. Howland, H. C. Mildram, F. M. Miner, H. L. Patterson and F. O. Whitney.

NOYES, JOHN H. L., Boston, Mass. (Age 43, b. Boston, Mass.) Studied at Boston College 1894-1897 and privately later. He entered the employ of the City of Boston in 1897 as rodman and worked up to junior engineer; carried on private engineering evenings from 1902-1918. He is at present chairman of the Board of Street Commissioners of Boston. Refers to A. Howland, H. C. Mildram, L. J. Monahan and F. O. Whitney.

O'FARRELL, MICHAEL DENIS, Boston, Mass. (Age 50, b. Chicago, Ill.) Graduated from Holy Cross College 1891; then took a two years course in structures at Franklin Union. Was transitman and assistant engineer on Boston Board of Survey work under the Commission for fifteen years; at present is assistant engineer in the Street Laying Out Department. Refers to N. J. Holland, J. McNulty, J. E. L. Monaghan, L. J. Monahan and F. O. Whitney.

REED, ALONZO B., Boston, Mass. (Age 33, b. Lowell, Mass.) Educated in the public schools of Lowell and later took courses in mechanical engineering in I. C. Schools, also civil engineering in American School of Correspondence. Has held positions as draftsman and engineer constantly since 1906 and is at present practicing both mechanical and civil engineering. Refers to A. W. Benoit, F. M. Gunby, C. T. Main and W. F. Uhl.

RUSSELL, ELWYN LEWIS, Boston, Mass. (Age 55, b. Boston, Mass.) Educated in the public schools of Cambridge, and special courses in mechanical and free hand drawing, International Correspondence School. He was with Childs Machine Co. as mechanical draftsman 1885-1886; Boston Heating Co., 1887; general drafting with Walter S. Coffin, 1888; with Aspinwall & Lincoln 1889-1891; with City of Boston, Board of Survey, 1891-1895; Engineering Department 1895-1911; Street Laying Out Department 1911 to the present time. Refers to F. H. Fay, H. C. Mildram, J. E. L. Monaghan, L. J. Monahan and F. O. Whitney.

SCANNEL, RICHARD ALBERT, Dorchester, Mass. (Age 33, b. Hull, Mass.) Educated in the St. Augustin Academy in Hartford, Conn., St. Joseph's Academy at Wellesley Hills, also a college in New York City. From 1911 to 1917 he was a rodman in the Sewer Service of the City of Boston; 1917-1922 he has been, and is, instrumentman in the same division. Refers to

E. S. Dorr, C. S. Drake, G. F. Haskell, F. A. Lovejoy, J. E. L. Monaghan and E. F. Murphy.

SHERMAN, GEORGE HUTCHINSON, Boston, Mass. (Age 47, b. Auburndale, Mass.) Educated in the public schools of Lawrence, Mass., where he fitted for Tech. He spent two years in steam-fitting and machine shop work; 1896-1898 in the office of C. H. W. Wood, engineer and surveyor; in 1898 he held the position of transitman in the Engineering Division, City of Boston, where is still employed. Refers to E. S. Dorr, F. H. Fay, H. C. Mildram, F. M. Miner, E. H. Rogers and F. O. Whitney.

STAFFORD, ROLAND GROVER, Attleboro, Mass. (Age 35, b. Attleboro, Mass.) Graduate of Tufts College in structural engineering. Was draftsman with Stone & Webster, Inc., a part of 1914; in March 1915 he entered the employ of the Boston & Maine R. R. as assistant bridge inspector, in December of that year became bridge inspector on the Terminal Division and in July 1916 was transferred to office of Engineer of Structures as structural draftsman; from May 5, 1917 to August 15, 1919, served in the U. S. Army; September 1919 he returned to the Boston & Maine as structural draftsman where he is at present employed. Refers to H. C. Archibald, A. Q. Robinson, B. W. Guppy, P. Jones and A. W. Knowlton.

STEVENS, FRANK BURTON, Newton, Mass. (Age 28, b. Brookline, Mass.) Educated in the public schools, Phillips Exeter Academy, a year at Dartmouth College and a year at Mass. Inst. Tech. In 1915 to June, 1917 was instrumentman, inspector and assistant to resident engineer on construction of two coal handling plants; June, 1917 to April, 1919 with the U. S. Army; 1919-1920 general superintendent of building construction, with Leahy & Rattigan Construction Co.; from this time to September, 1922 with Haven & Hopkins as structural engineer. Refers to W. M. Bailey, H. K. Barrows, C. R. Gow, J. H. Libbey and W. A. Woods.

SULLIVAN, THOMAS F., Allston, Mass. (Age 52, b. Cambridge, Mass.) He has been employed in the Street Laying Out Department of the City of Boston as rodman and transitman and is at present filling the latter position in this department. Refers to A. Howland, H. C. Mildram, J. E. L. Monaghan, L. J. Monahan and F. O. Whitney.

SULLIVAN, WILLIAM JOHN, Boston, Mass. (Age 50, b. Boston, Mass.) Graduated from the Scituate High School in 1890 and entered at once the City Surveyor's office as rodman; passed examination as transitman in 1900 and as senior engineer in 1907; at the present time is assistant engineer in the Street Laying Out Department, City of Boston. Refers to C. H. Gannatt, A. Howland, E. H. Lincoln, H. C. Mildram, E. F. Murphy and F. O. Whitney.

WEEKS, LAWRENCE E., Malden, Mass. (Age 30, b. Everett, Mass.) Studied railroad engineering at Boston Y. M. C. A., structural engineering two years at Franklin Union, and took several years with the International Correspondence School. 1911-1912 was a rodman with Brookline Engineering Department; July 1912 - December 1916 was with Boston Transit Commission as rodman, transitman and draftsman; from September 1918

to the present structural draftsman with the Boston & Maine R. R. Refers to H. C. Archibald, R. B. Farwell, B. W. Guppy, P. Jones and L. B. Manley.

WHITMAN, KILBORN, JR., Boston, Mass. (Age 38, b. Boston, Mass.) Graduate of Mass. Inst. Tech. in 1905; 1905-1907 was assistant in the Civil Engineering Department at Tech.; 1907-1909 instrumentman and assistant engineer on water power and flood prevention for New York State Water Supply Commission; 1909-1914 was assistant engineer in the designing division of New York City Board of Water Supply, and in the filtration division of New York City Department of Water, Gas and Electricity; 1914-1916 held the same position with the Water Department of Cleveland, O.; 1916-1921 assistant designing engineer Hartford Board of Water Commissioners; is at present employed by Metcalf & Eddy. Refers to E. E. Pettee, C. M. Saville, J. P. Wentworth and L. P. Wood.

LIST OF MEMBERS.

ADDITIONS.

DREW, SAMUEL T.....42 Bradford St., Quincy, Mass.
HAGEMAN, HARRY A.....147 Milk St., Boston, Mass.

DEATHS.

BIDWELL, LAWSON B.....November 19, 1922
COGGESHALL, R. C. P.....October 20, 1922.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Water Supply Papers 482 and 484.

State Reports.

Massachusetts. Report of Department of Public Health. 1920.

Wisconsin. Inland Lakes of Wisconsin. Wisconsin Geol. and Natural History Survey.

New York. Special Report on Municipal Accounts. State Comptroller.

Municipal Reports.

Fall River Mass. Annual Report Watuppa Water Board. 1921.

Medford, Mass. Annual Report Water and Sewer Commissioners. 1921.

New York, N. Y. Annual Report Bureau of Buildings. 1921.

Newton, Mass. Annual Report Street Department. 1921.

Northampton, Mass. Annual Reports City Officers, 1920 and 1921.

Miscellaneous.

Descriptive Geometry, Young & Baxter; Engines and Boilers, Thomas T. Eyre; River and Harbor Construction, Townsend, Gift of Dugal C. Jackson.

Shield and Compressed Air Tunneling, Hewett & Johansson, Gift of McGraw-Hill Book Co.

Talc and Soapstone in Canada. Department of Mines, Canada.

LIBRARY COMMITTEE.

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

**CONSTRUCTION OF A PRE-CAST CONCRETE SLAB
BRIDGE AT CENTRAL STREET, LOWELL.**

By S. STANLEY KENT,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented October 18, 1922.)

IN so far as we know, there is but one water power company in this state that is responsible for the maintenance of bridges on the public highways. It is the great misfortune of the Proprietors of the Locks and Canals on the Merrimac River at Lowell to be that one company. The charter which was granted the Proprietors by the General Court in 1792, for the purpose of promoting navigation, placed certain obligations for the maintenance of bridges over the Pawtucket Canal on the navigation company. About 1821, the rights of the Proprietors of the Locks and Canals were purchased by the Merrimac Manufacturing Company, additional canals were dug, other manufacturing companies were interested to take part in the enterprise, and the development of water power used mostly for textile manufacturing became a more and more important use of the system, while with the coming of the railroads the use for navigation gradually died out. But the bridges are still with us.

Among them is the Central Street bridge over the Lower Pawtucket Canal. At this point the canal is about 80 ft. wide with a pier in the center which divides the Canal into two skew spans each from 40 to 45 ft. in length measured in the direction of

*Assistant Engineer, Proprietors Locks and Canals, Lowell, Mass.

the roadway. The average width of the street is about 65 ft., nearly 28 ft. of which is taken up by the two sidewalks. Of the 37 ft. between the curbs, the central 15 ft. or so are occupied by two car tracks. The first bridge over the canal at this point was built sometime between 1792 and 1796, at which latter date the canal was opened. The bridge was rebuilt in 1836, again in 1850 and still again in 1883. It was the bridge built in 1883 that was replaced this last summer. That bridge was built of queen post trussed stringers spaced about three feet on centers. Each truss consisted of two 7-in. x 14-in. stringers with a $1\frac{1}{2}$ in. diameter wrought iron truss rod in between. The construction was described as follows by Mr. James B. Francis, under whose direction the bridge was built.

"The stringers are of southern pine, the under planking $2\frac{1}{2}$ -in. spruce, planed to a thickness of $2\frac{3}{8}$ -in., matched and jointed and laid as tight as practicable, and strongly spiked to the stringers covered with coal tar of the kind used for concrete sidewalks put on hot and while soft, the top plank of 3-in Canada Pine jointed but not planed was put on and spiked to the plank under it, the spikes not going through.

"The surface of the roadway and sidewalks is of coal tar concrete $3\frac{1}{2}$ -in. thick put on hot, costing \$1.00 per sq. yd. The part of the same between the rails of the Horse Railroad track was paid for by the Horse Railroad Company.

"The work was all done without interrupting the ordinary travel or the use of the Horse Railroad. The pier with the exception of the capping was completed before the roadway or sidewalks were disturbed.

"The roadway was divided into three divisions, the middle division including the Horse Railroad, was first taken up and rebuilt, the Railroad having been first moved to the westerly side and the ordinary travel provided for on both the side divisions. When the middle division was completed, the ordinary travel was provided for on it and the westerly side division, and the other side division were taken up and rebuilt. When this was completed the remaining division was taken up and rebuilt."

It will thus be seen that a precedent was established for the reconstruction of the bridge without undue inconvenience to the public.

The construction of the 1883 bridge was begun on July 22, and completed on October 12. In 1900 the trussed stringers under the street railway tacks were replaced, and in 1907 strengthened again. In 1912 they were replaced by four steel girders which were not disturbed during the reconstruction of the bridge last summer. Outside of the section occupied by the Street Railway tracks, the bridge had required no repairs since 1883 excepting for the wearing surface, which in recent years had required extensive patching almost annually. When taken out the main timbers were found perfectly sound, as was also most of the planking outside of those parts near the Street Railway section and the curbs. The cause of renewing the bridge was the poor condition of the wearing surface and the excessive vibration of the entire bridge due to modern heavy loads.

The density of traffic on Central Street made the reconstruction of the bridge something of a problem. The bridge is within two and a half blocks of Merrimac Square which is the traffic center of Lowell, and it is hardly an exaggeration to say that virtually one half of the City of Lowell is reached by way of Central Street. There is no parallel street in the near vicinity over which traffic could be diverted. Electric cars pass over the Central Street bridge at the average rate of seventy per hour from five thirty in the morning until eleven thirty at night. To close even one half of the bridge for any length of time would cause serious inconvenience to the public.

The situation was further complicated by the fact that there have been business blocks put up over the canal on both sides of the bridge, with five store entrances to be kept open on the upstream side of the bridge and six entrances including the Strand Theatre, on the downstream side. The Strand is Lowell's largest moving picture theatre. The platforms over the canal on which these buildings are located are owned and leased by the Locks and Canals, and although the leases contain clauses reserving the right to rebuild the bridge, yet a moral if not legal obligation was felt to cause the minimum of inconvenience.

The situation was somewhat complicated from the structural side by the pipes and conduits which cross over the canal under the bridge. On the upstream side is a 16-in. city water main and a 12-in. gas pipe, both supported by independent trusses, and also a conduit containing a cable supplying a series current to the "White Way" lights, with one of the lamp posts located on the bridge. This conduit was hung from the bridge, as are also a nest of electric light conduits and a group of telephone cables which cross the canal on the downstream side.

Furthermore it is a skew bridge in the superlative degree. The lines of the abutments and the center pier all form angles with each other, and the same is true of the building lines and the curbs. There is no such thing as a right angle in the bridge.

It will thus be seen that the conditions called for a type of bridge which could be erected in the minimum of time and could be thrown open to traffic as soon as completed. Pre-cast concrete slabs were suggested by Mr. W. H. Durfee and seemed to meet these requirements best, and bids on this type of construction were called for by Mr. Arthur T. Safford, Chief Engineer of the Locks and Canals.

The design submitted by the New England Structural Company made under the direction of their Chief Engineer, Mr. E. N. Pike, was accepted. The plan as finally carried out was as follows:

Three 30-in. Bethlehem I-beams support the roadway on each side of the street railway tracks, with a 28-in. and a 26-in. Bethlehem beam under each sidewalk. The roadway girders are braced at eleven foot intervals with 10-in. I-beams, the tops of which are set flush with the tops of the main girders and with them form a quadrilateral of steel to support the pre-cast slabs. The slabs were designed to average about 11 ft. in length by 5 to 6 ft. in width and 7 in. to 12 in. in thickness. This gave a weight of from 4 to 5 tons for each slab. The bridge is on a slight grade. This and also the crown of the bridge were taken care of by setting the tops of the I-beams horizontal and varying the thickness of the slabs. The slabs were designed for the standard 20-ton truck as specified by the State Department of Public Works. Five-eighths-inch round reinforcing rods were used

in both directions with every alternate rod bent up at the ends. The edges of the slabs were recessed a half inch for a width of 5-in. to 10-in., so as to let them fit down into the steel work. Kreolite wood blocks were laid on top of the slabs to form the wearing surface. It was at one time suggested that perhaps the tops of the slabs themselves could be used as the roadway surface, but the idea was abandoned for fear that the slabs would chip on the edges and that patching would prove difficult. The wood blocks were preferred to granite partly because of their lightness and smoothness, but more especially on account of the greater time required before the granite blocks could be thrown open to traffic. The pre-cast slabs were made for all of the roadway outside of the street railway area and for one half of each sidewalk. The outer half of the sidewalks next to the building lines was poured in place. Base plates to carry the main girders were set in the abutments and the center pier previous to the reconstruction. It was proposed to rebuild one half of the bridge between Saturday night and Monday morning, excepting for that half of the sidewalk to be poured in place, and repeating with the other half of the bridge on the following week end.

Under an arrangement satisfactory to the Proprietors of the Locks and Canals, the R. E. Runnels Construction Company of Lowell took the general contract for the reconstruction of the bridge in accordance with the design of the New England Structural Company, with the New England Structural Company furnishing and erecting the steel work, and the Locks and Canals setting the base plates and doing other preliminary work.

The base plates were set during the months of May and June of this year. Some little work was involved, as pockets had to be cut in the masonry abutments, many of which unavoidably came directly under the ends of the old trusses and necessitated shoring up from the bottom of the canal. In addition to this the Locks and Canals faced up the south abutment with concrete and carried the foundation down to hard pan. The original south abutment consisted of a rough stone wall laid dry and was founded on 3 to 4 ft., of black muck underlaid with hard pan. About a third of the abutment rested on short piles driven through the muck. The concrete, put

on averaged about a foot in thickness, with a sloping footing four to five wide which reached back under the old wall. This work was done in sections on three successive Sundays with the water drawn out of the canals.

The pre-cast slabs were made by the R. E. Runnels Company in their yard on Thorndike Street about three quarters of a mile from the bridge.

1: 2: 4: concrete was used. Each slab had four "U" shaped hooks made of $\frac{7}{8}$ -in. reinforcing steel cast into it for handling. These hooks were burned off after the slabs were finally placed. Steel curb edgings were cast in the sidewalk slabs to form the curb. After curing for about twenty days the slabs were all raised and their dimensions carefully checked and any irregularities corrected.

With all preparations completed, the week ends of July 16 and July 23 were set for the reconstruction of the bridge. During the days preceeding these dates the street railway tracks including both rails and ties and the planking and pavement between the rails were all renewed. Both in and outbound cars used the easterly track during the week of July 10 to 15, when the westerly track was relaid, and the situation was reversed the following week. During these periods both side of the bridge between the tracks and the curbs remained open to traffic.

Eleven o'clock Saturday night, July 15, was set as the zero hour for the replacement of the westerly half of the bridge. At that hour the street was entirely closed with the exception of the easterly sidewalk, the New England Structural Company began the erection of their derrick, and the Runnels Construction Company started in tearing up the tar concrete wearing surface. It was hard and tough and thick. Two or three hours work with hammers and wedges made little impression, but yet enough to open up the way for their trump card. This was an Erie steam shovel which came lumbering onto the scene in the early evening, spitting water and steam like an angry dragon. Holes were cut through the bridge planking after wedging off the tar concrete and through these holes a husky chain was passed and made fast to the bucket of the steam shovel. The steam

shovel then sat back on its haunches and reared and tore and snorted and snarled. "The 3-in. Canada pine, jointed but not planed" which Mr. Francis had laid "on the under planking of 2½-in. spruce planed to a thickness of 2⅜-in. matched and jointed and laid as tight as practicable and strongly spiked to the



FIG. 1. — CENTRAL STREET BRIDGE, WEST SIDE, JULY 16, 1922.

stringers" came up reluctantly, but it came nevertheless. The use of the steam shovel reduced this operation which might well have taken a day or two if done by hand to a matter of hours. The steam shovel was also used later for placing the slabs. By eight o'clock on Sunday morning that half of the deck over the southerly span was removed so that the New England Structural Company was able to start lifting out the old trusses and putting in the new I-beams. The work was carried on continuously through Sunday and Sunday night with the traffic still shut off. When Monday morning came the roadway slabs were all in

place and part of the sidewalk slabs. It was then necessary to suspend operations until Monday night in order to open up the easterly half of the bridge for traffic and to place short wooden bridges into the store entrances. The remaining sidewalk slabs were placed in position Monday night, and the kreolite blocks



FIG. 2. — PLACING CONCRETE SLAB, CENTRAL STREET BRIDGE, EAST SIDE, JULY 23, 1922.

laid. The roadway and one half of the sidewalk was all completed and opened up at 11 o'clock Tuesday morning. The actual working time required for replacing this half of the bridge was something under sixty hours.

The electric cars were diverted to the rebuilt westerly track on Monday morning and during the week the easterly track was replaced and new pavement laid. During this period with the exception of Monday, both sides of the roadway and the westerly track were again open for traffic. One way traffic only was permitted on Monday.

The work was repeated in a similar way with the easterly half of the bridge the following week end. Due to the experience gained on the first half of the bridge, the work progressed more rapidly. The old deck was entirely removed by 6 A.M. Sunday morning, the old trusses all lifted out by 11 A.M., and the new



FIG. 3 — CENTRAL STREET BRIDGE AS COMPLETED, JULY 31, 1922.

steel work placed and riveted by 7 o'clock Sunday evening. The placing of the slabs began at 4 o'clock Sunday afternoon and was completed by midnight Sunday night. This was two hours in advance of a schedule which called for opening the entire bridge for traffic at 8 o'clock Monday morning. But the heavens intervened. A steady rain Sunday afternoon and night of course made it impossible to lay the wood blocks in pitch. It was the middle of the week before the pavement could be laid, although with both the railway tracks and the westerly half of the bridge already completed the traffic could go in both direc-

tions. The remaining half of both sidewalks were poured in place during this week.

Great credit is due the R. E. Runnels Construction Company and the New England Structural Company for the energy and ability displayed in carrying out the work substantially in accordance with the original schedule.

BOSTON SOCIETY OF CIVIL ENGINEERSFOUNDED 1848

PAPERS AND DISCUSSIONS

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STRENGTHENING OLD BRIDGES.

By LEWIS E. MOORE,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented October 18, 1922.)

PERHAPS the most important question that arises in considering the strengthening of an old bridge is what loads the bridge will actually be called upon to carry. In the design of a new bridge this question is not so important because the current practice which requires new structures to carry from 80 to 100 pounds per square foot, together with a heavy load concentration such, for instance, as a 20-ton truck, will adequately provide for all usual traffic conditions with a considerable margin for future increase in loads.

New bridges should not be designed to take care of very occasional unusual heavy loads such as steam shovels and other equipment because it is not justifiable to spend public funds to accommodate occasional very heavy loads that are entirely out of the run of ordinary traffic. It is usually easy to lay skids, which will serve to distribute these very heavy loads and so make it safe to move them over the structure. Such provision should be made wholly at the expense of the man who desires to move the unusual load.

Another type of the load problem may arise where an old bridge is operated under traffic restrictions. A case in point is

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the Slade's Ferry Bridge over the Taunton River at Fall River. This bridge has two decks, the upper one carrying electrified steam railroad tracks and the lower one carrying a highway with two trolley tracks. The electrified steam road traffic consists of light cars run in trains of two or three. The restrictions on the bridge were based on the capacity remaining for highway traffic when a steam operated freight train was on the bridge. After the restrictions had been in force for years someone woke up to the fact that the steam train crossed the bridge only twice a day, at about 2 A.M. and 4 A.M. and that at all other times the railroad load was so light that the highway traffic restrictions could be practically removed.

Before the advent of the motor truck, specifications for bridges generally provided for a distributed load of anywhere from 60 to 100 pounds per square foot, and a concentrated load consisting either of a heavy wagon or a steam roller, weighing anywhere from 10 to 15 tons. Very rarely was a single load greater than 15 tons provided for. The advent of motor transportation produced different conditions of loading. To meet these conditions heavier concentrated loads are provided in new specifications, but not much heavier distributed loads.

The specifications of the Massachusetts Public Utilities Department provide for a 20-ton motor truck, which is supposed to be heavy enough to take care of almost any load that may come on the bridge. This load is not yet commonly met with. Within my own experience in the last two years a truck has been operated in the city of Lowell weighing about twenty-two tons. The average is considerably under that and, as a matter of fact, 15 tons is not often exceeded. There are certain trucks regularly carrying cotton from Boston to New Bedford and Fall River which weigh 16 tons.

In studying old bridges inexperienced engineers are very apt to take the latest specification for highway bridges which they can obtain, and study the bridge with reference to the design loads provided in these specifications. If it is incapable of carrying the heavy loads now specified for new designs they condemn it and quite commonly recommend that a new bridge should be built. This is by no means always necessary.

There are a large number of bridges throughout the country which, because of the increasing amount and changed character of loads on the highways, now appear to be obsolete and nearly useless. It is often possible, however, by careful consideration and planning, to get a number of years additional service out of such old structures at a moderate cost. The first element to consider is that of actual loads.

I have a few facts with regard to actual loads from automobile traffic to present. My own car weighs, ready for the road, without passengers, 3 290 pounds, with five passengers it weighs about 4 000 pounds. It is 5 feet 6 inches wide and 15 feet long over the bumpers, and so covers an area of a little over 80 square feet. Four thousand pounds distributed over an area of 80 square feet gives just 50 pounds per square foot. A certain seven passenger touring car of a different make weighs 3 800 pounds, without passengers. With seven passengers, ready for the road, it would weigh about 5 000 pounds. Being 18 feet long over bumpers, it covers a roadway area of practically 100 square feet, which again gives a weight of 50 pounds to the square foot. Ford cars, which constitute the majority of those met on the road, weigh considerably less per square foot. If it were possible to pack a roadway full of automobiles touching each other on all sides you would get then an average load of about 50 pounds per square foot with occasional heavier concentrations, due to trucks. As a matter of fact, such a loading is rarely, if ever, met with.

The actual average loading over the whole roadway may be arrived at by considering traffic on congested city streets. In this case the number of lines of traffic must be considered in order to get the average load per square foot. As an instance, consider the double deck bascule bridge on Michigan Avenue in Chicago. The top roadway is 50 feet wide and I can safely state, having observed the bridge immediately after an opening, that six lines of traffic are all that can be accommodated. For example, the cars I referred to previously weigh 270 pounds per foot of length. Six lines of them would weigh 1 620 pounds per lineal foot. The average weight per square foot of roadway is obtained by dividing 1 620 by the width of the roadway or 54

feet. This gives 30 pounds per square foot as an average. This assumes that the cars are touching fore and aft, but not on the sides. Beacon St., Boston, alongside the Common, averages about 40 feet wide, as measured from a city atlas. It accommodates only four line of traffic. Multiplying four by 270 and dividing by 40 gives 27 pounds per square foot on the assumption that each car is touching the next preceding one. Beacon St., between Park and Tremont, is only about 25 feet wide and will only accommodate three lines of cars. Multiplying 3 by 270 and dividing by 25 gives 32 pounds per square foot. Some passenger cars are heavier than those above mentioned, but this is offset by the fact that cars do not touch each other, front and rear, as they are proceeding along the road, so that the length assigned to a car in the above discussion is actually too small. It would appear then that the present type of passenger cars will give an average load concentration on a roadway not greater than 30 or at most 35 pounds per square foot. My own belief is that the smaller figure is more nearly correct.

Now suppose we have an old bridge designed for say 80 pounds per square foot live load, in addition to sufficient capacity to carry its own dead load. If you subtract the average actual live load of 30 pounds per square foot from the 80 pounds live load capacity, you will have 50 pounds per square foot left, which may be regarded as excess live load capacity over and above the actual requirements of traffic. A considerable proportion of this 50 pounds per square foot excess capacity can be used to add material which will strengthen the bridge. In the case of an old structure, it is certainly good judgment to do this, provided the cost of such repairs is less than the cost of a new structure. It is poor economy to throw away a bridge, when at a moderate cost some of its excess live load capacity can be used to strengthen it. In these days of high taxes the taxpayers cannot afford to have their money spent in building new structures unless the economic conditions affecting the bridge under consideration warrant a new structure.

The motor truck must not be lost sight of, but as a general proposition all that is required is to design the floor strengthening so as to care for the concentration which it may produce at any given point.

Sometimes old bridges are condemned because of their vibration under modern loads. I know by experience that proper strengthening will practically eliminate this difficulty. Old bridges are sometimes condemned because they have some certain type of detail. For instance, the hanger used in suspending floor beams from pin trusses is quite often the cause of condemning an old structure. I have examined thousands of bridges, many of them with hangers, and while I have found hangers improperly adjusted and without sufficient provision for transference of load from floor beam to hanger, I have yet to find a broken hanger of this type. I venture to say that such broken hangers are much less frequently met with than are cracked riveted connections. Bridges with this detail can often, by a little judicious strengthening of the detail connecting the hanger to the floor beam, be made sufficiently strong for modern loads.

I have a few instances which illustrate what may be done in strengthening old bridges. The first one is a small bridge involving many of these points mentioned above. It has a span of 127 feet, with trusses spaced only 13 feet on centers, and is located in the city of Northampton. Traffic over it is not heavy, though occasionally a heavy truck uses it. The bridge is of wrought iron, built some time prior to 1885. All of the tension members are loop-rods. Many of the details, particularly of the top lateral system, would not be used to-day. Careful inspection showed that all parts were in good condition. The floor consisted of iron floor beams with wooden stringers and a three-inch wooden plank floor. A Ford car passing over the bridge would cause a tremendous vibration and rattling of the structure. As it then stood, I limited the loads on it to two tons, but after a little study decided that it would not pay to throw away the old bridge. Traffic conditions were such that there never would be any necessity for a wider roadway. The bridge was apparently originally designed for 80 pounds per square foot live load and the dead load amounted to about 30 pounds per square foot. After strengthening, the total dead load was about 60 pounds per square foot, which absorbed 30 of the 80 and so left 50 pounds per square foot live load capacity. The individual details are such that it will also carry a single 20-ton truck.

The strengthening consisted of putting in new hangers, new steel floor beams, new steel stringers and a 4-inch concrete slab floor. It was impracticable to connect the laterals at the bottom of the posts without incurring considerable expense. Inasmuch as the concrete slab floor, when completed, would render a lateral system unnecessary, I decided to attach the lateral system to the bottoms of the outer stringer at points close to the floor beams and to make them of rods with threaded ends. A nut at each end served to tighten the lateral enough to hold it in place and stiffen the bridge laterally until the floor slab was completed. In handling this job in the field, we took out not over two panels of the floor system and laterals at a time in order to prevent the bridge from collapsing sidewise.

The design of the parapet is novel. In most highway bridges one of the sources of serious trouble is the accumulation of dirt and debris on the bridge seats. This is rarely swept off and usually rusts out the points of support. The parapet was designed to eliminate this difficulty. In principle it consists of building a parapet whose coping is at the same height as the top of the curb and which extends a sufficient distance beyond the trusses to adequately protect them from dirt and debris. The parapet is notched out at the right height to support the floor slab, together with its curbs. The floor slab, when it is poured, must be prevented from bonding to the parapet. The strengthening entirely eliminated the vibration. The total cost was \$3 778.50, about \$2.29 per square foot.

Another type of bridge strengthening which possesses some unusual features and may be of interest was that of two lattice truss spans 160 feet long, (Fig. 1). The town having charge of the maintenance of this bridge found it necessary to replace the existing wooden floor and decided to replace it by pre-cast concrete slabs resting on the stringers. After the slabs were cast, certain questions were raised which resulted in my being brought into the matter. After careful study of the situation, I made up my mind that the best course to pursue was to place the pre-cast slabs as planned and strengthen the floor system by placing intermediate floor beams in the center of each panel. These floor beams were riveted to the trusses at their ends and

supported by new hangers connected to the intersections of the truss, which was a quadruple system lattice girder. The collision struts at the ends of the trusses were the only original truss members which required strengthening. Stiffeners were riveted to the stringers at their centers and they were blocked up on the new floor beams by steel shims about three inches in height. The reason for making these shims so deep was to allow the existing

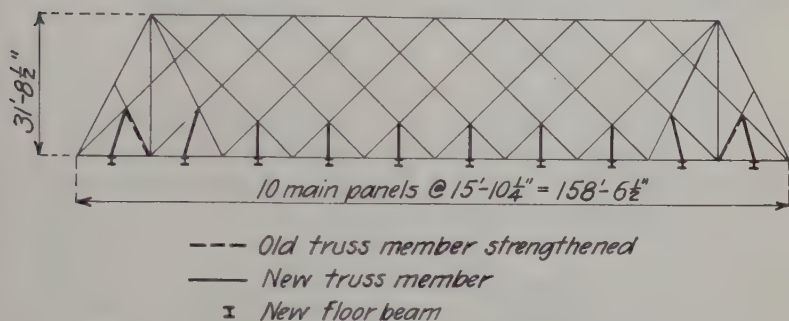


FIG. 1 — METHOD OF STRENGTHENING TWO LATTICE TRUSS SPANS.

lateral system to pass over the new floor beams without disturbance. There was one trolley track on the bridge near one truss. This method of strengthening not only doubled the strength of the stringers for concentrated loads, but also relieved each existing floor beam of nearly half of its dead load, thereby increasing its live load capacity. The construction recommended for the street railway track was steel ties with rails fastened to them and concrete slabs poured in place. This construction was afterwards modified for reasons which had nothing to do with the engineering feature of the situation.

Using a live load of 68 pounds per square foot with a single 20-ton truck and a 50-ton trolley car placed anywhere, the top chord would be overstressed in the center panel 13 per cent. and one of the tension diagonals would be overstressed the same amount. Inasmuch as it is doubtful if the average load on the highway ever exceeds 30 pounds per square foot, it is probable that the bridge is never actually overstressed at all.

Figure 2 shows an entirely different type of strengthening which was first installed in a bridge in Holyoke in 1914. The bridge consisted of two spans of very light continuous trusses over a water-power canal. The ice froze on one side of the stone masonry pier, with the result that occasionally it would tip 3 or 4 inches out of line. After the ice was melted, or cut away from the pier, it would settle back to its original position. This movement of the pier would damage the truss whenever it occurred. Because of the conditions, trolley traffic was discontinued over the bridge.

I was asked by City Engineer McCarthy to suggest a means of strengthening the bridge so that trolley traffic could be resumed. I suggested taking out the wooden stringers under the trolley track and substituting 15-inch Bethlehem girder beams, which would extend unbroken from each abutment to the center pier. Such beams are strong enough to support a 30-ton trolley car over the full span of 50 odd feet. The deflection of the beams alone, under such conditions, figures about 2 inches, but the actual effect of such beams is to distribute the load between the different floor beams and the longitudinal beams themselves. The actual result is that there is very little deflection, but a very great stiffening of the structure. A parapet was built on the center pier, thoroughly anchored to the bridge seat, as shown, and the girder beams were butted against this wall and also solidly against the parapet walls of the abutment, no room being left for expansion. The effect was that the pier never tipped again; the bridge was stiffened enough so that there was no perceptible deflection under trolley car traffic; and truck drivers used it in preference to other bridges over the same canal because of its stiffness. The cost of this work, which was done in 1914, was about \$1 200.00. The same scheme has been used in other places with similarly good results. In one case it was applied to a wooden truss bridge with very satisfactory results.

An entirely different problem was presented in the case of two spans, one a truss about ninety feet long and the other a girder about forty feet long (Fig. 3). This is a highway bridge with one street railway track at one side of the roadway. The bridge itself consisted of very light sections, very badly corroded,

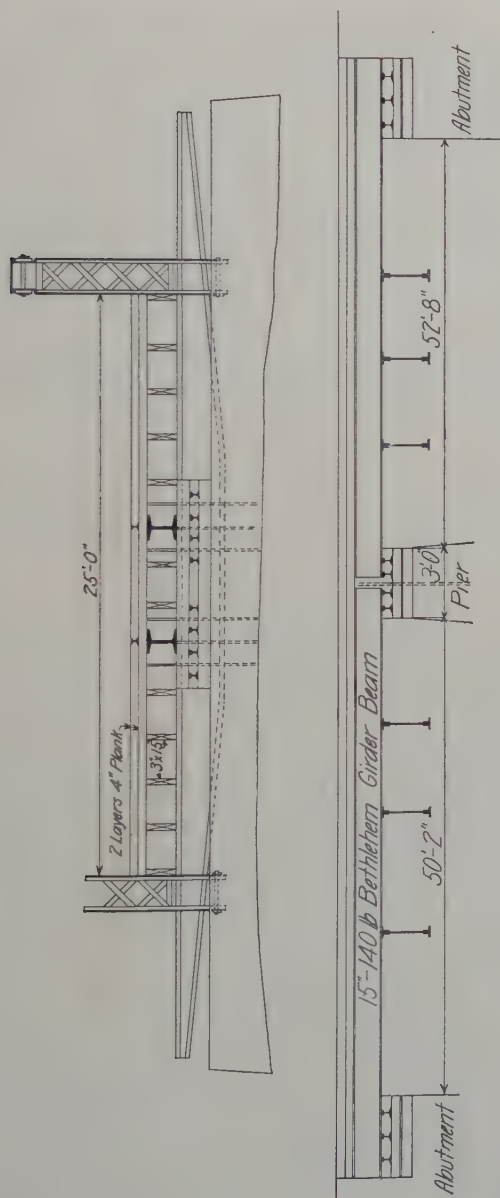


FIG. 2 — METHOD OF STRENGTHENING BRIDGE, AT HOLYOKE, MASS.

and beyond the possibility of strengthening in its entirety at any reasonable cost. The Street Railway Co., however, was desirous of strengthening its track.

Apparently the existing bridge had been preceded by three spans, probably of wooden stringers, as the debris of the old pier is still in existence in the middle of the truss span. There is considerable heavy rip-rap around the existing pier. This rip-rap and debris of the old pier are above the water level at

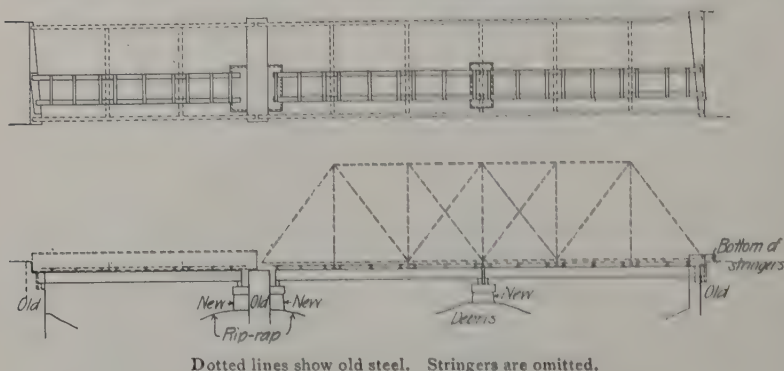


FIG. 3 — METHOD OF STRENGTHENING BRIDGE UNDER STREET RAILWAY TRACKS.

most times and have not altered their position in the last twelve years, to my own knowledge. I therefore decided to build a small concrete pier on the debris of the old one, two small buttress piers on the rip-rap around the existing pier and to notch out the existing masonry in the abutments for new bridge seats, all with the purpose of placing longitudinal girders beneath the existing stringers and transferring the load on the stringers to these girders, thus relieving the highway bridge of any responsibility for Street Railway loads.

The Street Railway stringers of the highway bridge are directly supported on new H's, extending crosswise from one new girder to the other. These H's are so located that they break up the individual stringer spans so that instead of being about fifteen feet, they become not more than 6 feet. This work is now in progress.

Some will undoubtedly criticise the placing of piers on debris and on rip-rap, as is done here, but it should be borne in mind that this debris has been unchanged for years and that even in the unlikely event of a wash-out of one of these piers, the old structure would still be there on its old supports. In this case I do not think that there would be any economical justification for going below the debris or rip-rap in order to obtain theoretically better foundations for the new masonry.

The new girders are placed by sliding them in sidewise on the piers and abutments and then jacking them up until the new H's bear on the under side of the old stringers. Castings are then put on the abutments and piers underneath the girders to carry them. These castings are about 15 inches deep in this case.

The above are a few illustrations of rather unusual methods of strengthening, each one of which was intended to be adapted not only to the purely engineering, but also to the economic requirements of the situation.

DISCUSSION.

B. W. GUPPY.* I have found Mr. Moore's paper very suggestive. It is our duty to get as nearly as can safely and economically be done, the last pound of service out of our bridges, and have repaired or strengthened fully 250 bridges in the last ten years. The word strengthening is often loosely applied to work that should be classed as repairs although to be sure the bridge is stronger after the work is completed than it was before. We are governed by the I. C. C. classification. Work that is done solely to restore the bridge to its original capacity is classified as repairs and charged to operating expenses. Work that is done to increase the original capacity of the bridge is classified as betterments and charged to capital account.

The two operations are similar. Ordinarily the work has to be done under traffic and with the least possible interference with traffic.

The necessity for repairs is due to neglect, accident, improper design and construction, overloading and malice afore-

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thought. The reason for strengthening is obvious. It is desired to put heavier loads on the bridge than it can safely carry in its present condition.

Our method of procedure is simple.

If there are no plans of the bridge available measure in detail. If there are plans check them against the structure. We have found enough variations between plans on file and structures in the field to make this rule obligatory. Make a thorough inspection at the same time to determine the necessity for repairs. Arrange to have the repairs made in connection with the work of strengthening.

The draftsman is required to take a set of prints to the site and sketch on them the location, nature and extent of all defects discovered. A stress sheet is next made for the proposed load and a careful investigation of all details. Studies are then made to determine whether the bridge can be strengthened to carry the proposed loads, whether safety or economy require the use of falsework and whether it will be cheaper to strengthen or to rebuild. Additional strength may be obtained by applying additional material to certain members, by replacing certain members with stronger members, by inserting additional members (including entire girders or trusses), or any combination of these three methods. Repairs are effected by cutting out defective and splicing in new material, by applying additional material or by revision of details. In making repairs due to failure of details plan the work to avoid a repetition of the failure.

Unless means are taken to relieve the member being strengthened of dead load stress the additional material will only carry its proportion of the live load stress plus the stress due to any dead load added to structure after member is strengthened. Members may be relieved of stress by forcing panel points apart or pulling them together or by wedging up the entire structure on falsework. In most cases it is cheaper to be liberal with the added material and not attempt to redistribute the dead load stress.

On account of the increased cost of doing work under traffic the greatest practicable amount of work should be done on the material before it is placed in its final position.

At first thought it would seem simpler to make good, loss due to corrosion by applying additional material, but it is generally more satisfactory to cut out the old and splice in new material. The irregular surface due to corrosion does not permit of close contact and tight rivets and the cost of thoroughly cleaning and painting same is disproportionately high. For this reason we now require top flanges of girders, floorbeams and built up stringers to have at least one cover plate the full length of the flange. Then loss due to corrosion can be easily made good by renewing the flange plate.

A carefully worked out program of operations is necessary in order that the work may be carried out safely and economically. A great deal of work can be safely done without any falsework being necessary. When there is sufficient time between trains, falsework for supporting dead load only and perhaps the construction equipment may be all that is necessary. In other cases falsework for carrying traffic may be required.

Most of the work done under traffic without the use of falsework consists in applying additional material or in cutting out and splicing in. When the truss has boxchords with double webs and I or H shaped web members, work on only one side of chord or web member of one truss at a time. On highway bridges confine traffic to one half of the roadway while working on the other side. When a truss has T shaped chords and web members, trestling is a necessity. We once had a very regrettable and unnecessary accident due to neglect of this precaution. A deck highway bridge had several lines of trusses. The interior trusses were double webbed, the exterior ones were T shaped. The bridge was over a busy station platform and it was planned to keep in falsework only while work on the outside trusses was under way. The foreman of the repair crew successfully repaired the interior trusses and without giving notice that he was ready to work on the outside trusses and without waiting for the falsework he had been told was necessary cut the flange angles off of one end post of an outside truss. The result was several casualties and some interruption to traffic, but no fatalities. No train was due and no passengers on the platform.

In one case the top flange angles only of the stringers of a single track deck truss of nine panels required renewal. As the

work had to be done under traffic it seemed simplest to renew the stringers between trains. The material cost would have been great. We bought two entire new stringers and the necessary flange angles for the others. The old stringers in one end panel were replaced by the new ones. New flange angles were riveted on this pair of old stringers and they were substituted in the second panel and so on till all stringers had been changed out and we were left with an old pair of stringers which were scrapped. The angles cut from the first pair of stringers were used as templates for drilling the new angles so there was no delay from this source. The only work done under traffic was cutting out and driving the rivets in the stringer connections.

The top of a number of bridge piers have been rebuilt or remodelled with the use of a minimum amount of falsework. Between trains the truss was jacked up on a bent placed near the pier and work of tearing out and rebuilding proceeded until a train was due, when truss was lowered onto blocking on pier to carry train. The new stones were cut to close fit so there was no delay. Concrete would have been cheaper per cubic yard but the cost of falsework to carry trains while the concrete was setting made the method adopted much the cheaper.

We are now completing our most extensive job of bridge strengthening. The bridge at Newburyport over the Merrimac River. The bridge is a double track bridge with seven fixed and a swinging draw span. The bridge consisted originally of three lines of trusses with floorbeams and stringers. We are placing two additional trusses midway between the present trusses and replacing the floor and bracing with stronger members. Traffic is confined to one track while work is under way on the other half of the bridge. No falsework is required. An entirely new structure would involve an additional expenditure of about \$80 000. A fuller account of this work will appear in an early issue of the *Engineering News-Record*. A word of caution in regard to trestling old bridges. A bent at the center of a Towne lattice truss is the proper method of strengthening; at the center of a Howe truss it is a crime. If a bent is desired near one end only, remember that web stresses are increased and investigate to see that members are not overstressed.

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**A LONG SPAN REINFORCED CONCRETE GIRDER
BRIDGE AT COHASSET NARROWS.**

By BARZILLAI A. RICH,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented October 18, 1922.)

THE Cohasset Narrows Bridge lies in the towns of Wareham and Bourne, Massachusetts. The Cohasset Narrows are located just west of the Buzzards Bay end of the Cape Cod Canal and connect Buttermilk Bay, a shallow tidal pond of some 500 acres in extent, with Buzzards Bay. The New York, New Haven and Hartford Railroad crosses the Narrows about one-half mile from Buzzards Bay. About 1891, a wooden pile highway bridge was constructed across the Narrows some 650 feet above the railroad bridge. Later a bridge carrying a street railway was constructed adjacent to and above the highway bridge. The highway crossing this bridge is the main highway to the south side of Cape Cod. Since the advent of the automobile the travel over this highway has increased very rapidly. The location of the old bridge was such as to require several dangerous curves in the highway between it and the village at Buzzards Bay Railroad Station.

The condition of the old highway bridge becoming such as to require its renewal, the Cohasset Narrows Bridge Commission, consisting of the County Commissioners of Plymouth and Barnstable Counties, was established by Chapter 165 of the General

* Of Fay, Spofford & Thorndike Consulting Engineers, 200 Devonshire St., Boston, Mass.

Acts of 1918 for the purpose of reconstructing the bridge. The Commission was given power to determine a new location so as to improve the alignment of the highway.

Studies for the location of the bridge had previously been made by the Massachusetts Highway Commission, which later became the Division of Highways of the State Department of Public Works, and the Commission determined on an approximate line for the new highway. This line was an extension of the existing highway in the town of Wareham across the Narrows with slight curve connecting it to the existing highway near the Buzzards Bay Railroad Station.

In November 1919, the Bridge Commissioners retained Fay, Spofford and Thorndike of Boston as engineers for the designing and construction of the new bridge. A careful study was made of several routes approximating the line above mentioned. Soundings were taken in the vicinity of the site and wash borings were made at the site to determine the surface and sub-surface conditions.

Measurements made showed that there had been considerable scour at the railroad bridge since it was reconstructed in 1912. The tidal range at the Buzzards Bay entrance to the Cape Cod Canal is given in the tide tables as 4.1 feet. This variation in tide caused a large volume of water to pass through the Narrows at each change of tide.

Current measurements were taken by means of wooden floats, having a draft of from $2\frac{1}{2}$ to 7 feet. The path of each float was obtained by locating its position by triangulation at about one minute intervals. The position of each float at the time of each observation was plotted and where necessary an interpolated point was plotted so that the distance between points was the approximate distance covered in a minute. In this way the direction of movement during any minute and the distance traversed was indicated on the plan. The paths of the floats used on flood tide were shown by solid lines and of those used on ebb tide by dotted lines. The greatest velocity was near the position of the second span from the north, and the floats drifted toward the location of that span. The contours interpolation from the soundings show this place to be the deep-

est part of the waterway. The average surface velocity was found to be about one foot per second or about seven-tenths miles per hour and the maximum velocity was about two feet per second or about one and four-tenths miles per hour at both ebb and flood tide. It will be noticed that the location chosen places the center line of the bridge practically normal to the current.

The borings showed the upper 10 feet of the soil to be very coarse sand and gravel. There were several large boulders above the surface, particularly on the Bourne side of the Narrows and the borings indicated that there were boulders in the underlying soil.

The Cohasset Narrows being navigable waters, it was necessary that provision be made for the installation of a draw if future conditions should warrant it. The draw in the railroad bridge, however, had not been opened during the previous twenty-five years so far as could be ascertained. The navigation in the Narrows and Buttermilk Bay is by pleasure craft and small fishing boats. As the existing railroad bridge gave a clearance which had proved satisfactory for many years, approximately the same clearance was adopted for the new bridge. The maximum clearance above mean high water is 9 feet at center span of the new bridge and 8.9 at the draw in the railroad bridge. These clearances proved satisfactory to the United States Engineers and the license was granted with the understanding that a draw could be installed if required in the future.

Many studies were made of various types of bridges such as steel girders, concrete arches and concrete girders of various lengths of span. The result of these studies was the adoption of a concrete girder bridge of five spans of 56 feet 6 inches each in the clear between copings of piers. (Figs. 1 and 2.) The arch bridge did not prove as economical as the girder bridge. The two principal reasons being that the arch bridge required that the highway be placed at a considerably higher elevation to provide sufficient clearance; and that, as provision for a draw was necessary, two of the piers would have to be of the abutment type and thus greatly increase the cost. It was found that the use of a 1 to 4.5 mixture of concrete was the most



FIG. 1 — COHASSET NARROWS BRIDGE.



FIG. 2 — COHASSET NARROWS BRIDGE.

economical to use. The higher allowable stresses permitted the use of longer spans for the same dead load than could be obtained with the 1.6 mixture commonly used for this class of work. The soil and water conditions being such as to make the construction of the foundations exceptionally expensive it was necessary to make the spans as long as possible to obtain an economical structure.

The bridge is 32 feet wide in the clear between side railings, there being a 26 foot roadway, with a 5 foot walk on one side and a 1 foot wheelguard on the other. The length of the bridge between faces of abutments is 303 feet. The piers are of sufficient length to permit the placing of an additional light girder outside the present side girders on the sidewalk side. By moving the present railing to the outer side of this girder a sidewalk can be constructed so that the present roadway can be widened to some 30 feet. This would then provide sufficient space for a railway track in the center with a line of vehicles on each side. It was assumed that the trolley line might be placed on this bridge when the existing street railway bridge should wear out.

The live loads adopted for use in the design of the slab and girders were as follows: For the slab a 20-ton truck with 25 per cent. for impact, each rear wheel being considered to be distributed over a width of 6 feet. For the interior girders a train of two 50-ton cars with 22 per cent. for impact, and one-half of a 20-ton truck with 25 per cent. for impact. For outside girders a 20-ton truck with 25 per cent. for impact. These live loads are those specified in "Specifications for Bridges Carrying Electric Railways," adopted by the Massachusetts Public Service Commission, Revised March, 1915.

The stresses in the concrete in the superstructure were kept within the maximum allowed by the Joint Committee report of 1916, that is, for the $1.4\frac{1}{2}$ mixture, they were as follows:

Bending	812 lbs. per square inch
Shear	125 lbs. per square inch
Bond	100 lbs. per square inch
Bearing	563 lbs. per square inch

The soil being sand, gravel and boulders to a depth of twenty or more feet below the surface, it was decided to place the foundations directly on it. The area of the waterway of the new bridge being only 22 per cent. greater than the existing railroad bridge, where considerable scour had occurred, the bottoms of the footings were placed about five feet below the ground surface.

The abutments are of the "U" type, the wingwalls being cantilevered in order to reduce the area of the cofferdams to a minimum. The concrete in the footing part of each abutment was placed under water within a steel sheet pile cofferdam having the same dimensions as the footing. The abutments are faced with granite from elevation 87.0, about one foot below mean low water, to elevation 96.0 above all but the extreme high tides, this part being alternately exposed to the sea water and the air. Above the granite coping, elevation 96.0, the abutment and wingwalls are of reinforced concrete. The highest water of which record could be found was 97.13, or about 7.00 above Mean Sea Level. The datum used being 90.13 below Mean Sea Level.

The piers are similar in construction to the abutments. There is, however, a course of concrete between the footing course and the granite facing on account of the greater depth of the foundations. The piers have curved cut-waters to reduce the obstruction to the flow of the water to a minimum. The tops of the piers are 6 feet 3 inches wide. A construction joint was placed 18 inches from the tops of the piers. This upper 18 inches contains the expansion bearings on one side of the pier and the fixed bearings on the other. These bearings were placed in position before this upper layer of concrete was deposited.

The piers were all designed considering that any span could be removed and a draw span substituted if necessary. The soil pressure was determined considering the maximum reaction from one span and the dead load only from the other span, the pier being submerged to low water only. The effect of removing one span and having the remaining span carry the maximum live load was also considered. The maximum soil pressure was about 6 000 lbs. per square foot.

The superstructure of each span of the bridge was composed of four longitudinal reinforced concrete girders each 59 feet center to center of bearing composed of concrete mixed in the proportion of one part cement to four and one-half parts of aggregate. The two interior girders were designed to carry a live load of a train of two 50-ton electric railway cars and the side girders to carry a live load of a 20-ton truck. The allowance for impact and the stresses allowed have been previously given. The ends of the girders were connected by a concrete cross beam and two light cross beams were placed between the outside and the interior girders at the third points. (Fig. 3.)

The deck of the bridge was made flat and the crown given to the roadway by filling to allow for a future railway track. A two-inch bituminous wearing surface was placed on the clean gravel filling. Small drains were placed through the slab to drain the filling. Scuppers were placed in each span to drain the roadway surface.

The expansion joints in the deck between the spans were formed by imbedding two steel angles in the upper edge of the slab and placing a 4 x 4 tee with its stem in the joint between the spans. A special detail was used at the curbs composed of a steel angle riveted to the tee and backed by a pre-molded expansion strip. These expansion joints have worked well and there is no indication on the surface of the roadway of the movement of the concrete structure. The expansion joints in the walls and railings are filled with heavy wool felt saturated with paraffin. At the time of a visit made about two weeks ago, the girders had expanded slightly due to the warm weather and the felt showed signs of having been compressed.

The conduits for electric wires were placed under the granolithic sidewalk. Movement at the expansion joints was provided for by reaming out a coupling attached to the pipe on one side so that the pipe from the other side formed a slip joint.

The long concrete spans meant that there would be considerable longitudinal movement due to varying temperatures, also that the bearing stress at the edge of a pier would be greatly increased by the deflection of a girder under maximum live loads. It was, therefore, decided to place the fixed end of the girders

on pin bearings so that the deflection of a girder would bring no excess pressure on the pier or abutment. The expansion end was placed on a single cast steel segmental roller thus providing a single bearing and preventing excess pressure at the edge of the pier and at the same time permitting that end to move longitudinally with ease. The fixed end bears on 2 inch steel pins, the only novel feature being the manner of connecting the upper casting to the girder. To connect this casting securely to the girder, ribs were cast to extend into the girder. These ribs ran in the direction of the length of the girder and were spaced so that the reinforcing rods passed between them. In this way any tendency of the girder to separate from the plate was obviated. (Fig. 4.)

A considerable amount of study was necessary to design a satisfactory expansion bearing before the one shown was decided on. The bearing decided on is both simple and efficient. It is formed of a 12-inch diameter segmental roller under each girder and provides for the deflection of the girder and for horizontal movement with one bearing. The two pins in each face of the roller prevent its working out of place. The upper casting of this bearing is designed the same as the upper casting of the fixed end. As this joint could not be examined in the future in the manner that it could be on a steel bridge it was decided to place it in a cast-iron box and fill the box with a heavy grease. This box was placed in upper course of concrete of the pier and the top of the box comes a short distance above the ordinary top of the pier. The casting attached to the girder fits over this box and forms a weatherproof joint. The joint between the pier and the girder was formed by a one-half inch layer of parafined wool felt.

The anchor bolts for the bearings were embedded in the part of the pier under the construction joint 18 inches below the top of the pier. The bearing plates were carefully adjusted in position by means of double nuts on the anchor bolts before the upper part of the pier was concreted.

The contract for the construction of the bridge was let to Holbrook, Cabot & Rollins on June 28, 1920 for the sum of \$200 000 for the bridge alone. Work was begun about July

20, 1920 and the bridge open to traffic July 2, 1921, the superstructure being all constructed in the spring of 1921. The work was started on the northerly or Wareham shore. For the north abutment and the northerly piers the area of the foundation was dredged approximately to grade and the steel sheet pile cofferdam then driven. Such little further dredging as was required was done inside the cofferdams. The southerly piers and abutment were constructed by first driving the cofferdam and then dredging the material inside. On this side there were several boulders within the cofferdam which required blasting. The piling was considerably damaged in driving and was very difficult to withdraw after the piers were constructed. As soon as the dredging in the cofferdams was completed, concrete was placed with bottom dump buckets to form the lower course of the foundation. This lower or footing course filled the area of the cofferdam and formed a seal. As soon as this concrete had set the cofferdams were pumped out and the remainder of the pier or abutment placed in the dry. The cofferdams proved to be sufficiently tight although the driving was very hard. After the completion of the pier and abutments all sheeting and piles were removed.

The forms for the superstructure were all made in a mill and assembled on the job. They were supported on piles which were pulled out when no longer needed. The steel reinforcing was erected on shore and carried to the girder and lowered into position as one unit. The railings were cast in place using a light colored aggregate. After the concrete had become hard the surfaces of the railings were bush hammered with 6 cut hammers. The finish obtained is both pleasing and durable. The lamp posts were pre-cast of the same aggregate as in the railings and while very simple in design add a great deal to the attractiveness of the bridge.

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MOSQUITO CONTROL IN MASSACHUSETTS.

By GEORGE C. WHIPPLE,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented before The Sanitary Section, October 4, 1922.)

By concerted action it will be possible to eliminate the mosquito nuisance in the inhabited parts of Massachusetts; it will not be practicable to eradicate all mosquitoes. At the outset we are confronted with a quantitative distinction hard to establish. How many mosquitoes does it take to make a nuisance? In the bedroom, one is enough; on the front porch or in the garden, one mosquito bite an hour as a maximum would not interfere seriously with outdoor life. It is not the occasional buzzing or biting of a mosquito which makes a nuisance; it is the concerted attack of half a dozen or perhaps a hundred and their continued presence day after day, which makes rational outdoor life impossible and which in many ways injures the health and comfort of the people. A practical measure of the mosquito nuisance may be found in the popular recourse to profanity. Three stages may be distinguished. In the first stage you swear at the mosquito, using any appropriate phrase from "Oh, dear!" to "Damn!"; in the second stage you swear at somebody because something isn't done; in the third stage you swear that you will do something yourself. For generations the people of Massachusetts have been swearing mad against the mosquito; last summer they became fighting mad. The Anti-

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Mosquito Association of Massachusetts was organized. Thanks to the coöperation of the press the people of the state know about this association, but the news does not seem to have reached the mosquitoes, for even at this date (October 4) they are still rampant. The object of this association as stated in its constitution is "to stimulate interest in the suppression of mosquitoes and other insects which affect human comfort and health; to secure and spread information and to urge coöperative efforts by individuals, associations, communities, and their governments to the end that these insect nuisances may be done away with." It was realized at the outset that little could be done until a substantial organization had been effected, definite plans made and funds collected, hence no efforts were spent in summer skirmishing. The fight against the mosquito will not be successful unless it has a plan of campaign based on scientific knowledge and put in operation over a wide area. It will be the work of the association this winter to arrange a plan of action and bring it to the attention of the cities and towns of the state, especially those of the Boston metropolitan area in order that the work of mosquito suppression may be undertaken early in the spring.

LIFE HISTORY OF THE MOSQUITO.

So much has been written about the mosquito that it is quite generally understood that this insect has a life cycle which includes three aquatic stages, the egg, the larva, and the pupa, and one winged stage, the mosquito. It is an accepted scientific fact that water is necessary for mosquito development, but mosquitoes are found so often in places where there is no apparent standing water that the public is still skeptical on this point. It is very easy to say that the female mosquito lays her eggs in water; that after a time these hatch and become larvae, or wigglers; which in turn become pupae, or tumblers; and that from the pupae the mosquitoes emerge and fly away. This indeed is the rule, but now comes the difficulty. Mosquitoes are not all alike. There are dozens of species, and the different species have different habits. Some mosquitoes lay their eggs in salt or brackish water, some in fresh water swamps, and some in

the rain water which collects in pools, puddles, gutters, tin cans, or even holes in trees. Other mosquitoes with faith in nature lay their eggs on damp ground where instinct tells them water will sometime come and remain long enough to hatch out their eggs. Some species have but one brood a year; some have successive broods as long as warm weather lasts and water can be found for eggs. I observed a curious fact last summer. The heavy rains of June and the succession of summer showers caused a tremendous mosquito crop at my home in Cambridge, while at my farm in New Hampshire there were fewer mosquitoes than for many years. Why this difference? The Cambridge mosquitoes were of the common house variety, which has successive broods all summer long. The Fitzwilliam mosquitoes were a Canadian woodland type which has but one brood and that early. The heavy rains of May and June (14.26 in. in June) washed the eggs and larvae out of their breeding places and carried them downstream. Few were left to trouble us. The early breeding habit of the species found at my farm is evidenced by the local saying that "when the flies come the mosquitoes go." There is no such saying in Boston.

Mosquito larvae have their differences. The larvae of most species live near the surface of the water or go to it frequently for aid; but there is one species that passes its larval stage at the bottom, evidently getting its oxygen from the roots of sedges. Applying oil to the surface of the water would not eradicate such larvae.

Mosquitoes differ in their winter habits. In some species the adult mosquitoes hibernate, hiding away in cellars and old buildings, usually in the dark, and emerging in the spring ready for business. In some species the eggs are laid in the fall, retain their vitality through the winter, though frozen, and hatch in the spring. In some species both the eggs and larvae withstand freezing.

Mosquitoes differ in their flying habits. The house mosquito seldom travels more than a few hundred yards from the place where it hatched; but the salt marsh mosquitoes often fly or are blown several miles. The mosquito which transmits yellow fever is a short flier; hence it is relatively easy to control it. The

mosquito which transmits malaria flies farther; hence in order to control malaria it is necessary to extend suppression activities over much wider areas.

Some mosquitoes take delight in entering houses and will seek out minute unprotected means of access, holes and cracks in screens, key-holes, chimneys; they will light on your shoulder while you are unlocking the front door and let you carry them in. Once in they will lay eggs in a water closet tank, or a vase of flowers, and people will wonder how they could possibly get through the screens. As a matter of fact few species of mosquitoes will get through a No. 16 screen; some mosquitoes will go through a No. 12. Some species seldom try to enter houses.

Without going further into details, it will be seen that in order to suppress the nuisance it is necessary to know what sort of mosquitoes we have to deal with, for measures appropriate to one species might be useless with another, and if improper measures are undertaken much money may be wasted, and discredit brought on the whole movement. Hence the problem is fundamentally one of entomology.

KINDS OF MOSQUITOES.

Entomological science has made great advances in recent years. New species of mosquitoes have been described by students in different parts of the world and given new names. In many cases the same sort of mosquito has been baptized with different names, both of species and genus, and inevitable confusion has resulted. This is equally true of all zoölogical science. Little by little entomologists are weeding out the duplicate names and giving permanent assignment of generic and specific titles warranted by priority according to the rules of scientific nomenclature. The result is that some names which have become well known are being replaced by earlier, though unfamiliar names. For example, the yellow fever mosquito is no longer *Stegomyia fasciatus* but *Aedes calopus*, and one of our Massachusetts friends is no longer *Culex sylvestris*, but *Aedes vexans*.

The best available treatise on the classification of the mosquitoes is Harrison G. Dyar's monograph on "The Mosquitoes of the United States," published in 1922, as No. 2447 in the Pro-

ceedings United States National Museum, Vol. 62, Art. 1, and reprinted by the United States Public Health Service.* It contains descriptions of the various genera and species with their synonyms and with references to localities where they have been found. Another recent and very excellent book is "Mosquito Extermination," by W. E. Hardenburg, published by McGraw-Hill, 1922, New York.

From Dyar's list we find that the following species have been found in Massachusetts. They all belong to the order of ⁶ Diptera, family Culicidae, and tribe Culecine.

LIST OF MASSACHUSETTS MOSQUITOES, COMPILED FROM
DYAR'S MONOGRAPH.

GENUS <i>Culex</i> Linnaeus	<i>Aë. hirsuteron</i> , Theobald
<i>C. testaceus</i> , van der Wulp	<i>Aë. dorsalis</i> , Meigen
<i>C. pipiens</i> , Linnaeus	<i>Aë. canadensis</i> , Theobald
<i>C. territans</i> , Walker	<i>Aë. excrucians</i> , Walker
<i>C. salinarius</i> , Coquillett	<i>Aë. stimulans</i> , Walker
<i>C. melanurus</i> , Coquillett	<i>Aë. cantator</i> , Coquillett
GENUS <i>Culiseta</i> , Felt	<i>Aë. fitchii</i> , Felt and Young
<i>C. dyari</i> , Coquillett	<i>Aë. cinereoborealis</i> , Felt and Young
<i>C. inornatus</i> , Williston	
GENUS <i>Mansonia</i> , Blanchard	<i>Aë. atropaltus</i> , Coquillett
<i>M. perturbans</i> , Walker	<i>Aë. taeniorhynchus</i> , Wiedemann
GENUS <i>Psorophora</i> , Robineau-Desvoidy.	<i>Aë. sollicitans</i> , Walker
<i>P. ciliata</i> , Fabricius	<i>Aë. triseriatus</i> , Say
<i>P. sayi</i> , Dyar and Knab	<i>Aë. vexans</i> , Meigen
GENUS <i>Aedes</i> Meigen	<i>Aë. cinereus</i> , Meigen
<i>Aë. trivittatus</i> , Coquillett	GENUS <i>Anopheles</i> Meigen
<i>Aë. aurifer</i> , Coquillett	<i>Aë. punctipennis</i> , Say
<i>Aë. intrudes</i> , Dyar	<i>Aë. quadrimaculatus</i> , Say
<i>Aë. punctor</i> , Kirby	<i>Aë. Walkeri</i> , Theobald

Of this list of thirty, which by no means includes all the known species, only about half a dozen play a major part in our mosquito nuisance.

* Our standard American work, "The Mosquitoes of North and Central America and the West Indies," by Howard, Dyar, and Knab, Carnegie Institution, 1912-1917, is now out of print.

I will not attempt to describe the various species in biological terms. This is beyond me and I will leave it to Dr. C. T. Brues, Assistant Professor of Economic Entomology, Harvard University, who has kindly consented to contribute to this discussion. I may say that while laymen may easily come to recognize the more common mosquitoes from their appearance, it requires a trained entomologist to make positive identifications, because the difference between species are often very minute and may involve a study of the male as well as female, and the larvae, as well as the mosquitoes themselves, a microscope being necessary to make some of the discriminations.

Perhaps it will be more useful for us to classify the common mosquitoes according to their usual habitat. We thus have these groups, which may be called the House Group, the Salt Marsh Group, the Fresh Water Woodland Group; to which may be added the Disease-Carrying Group. This classification, it must be admitted, is not a definite one, as there is some over-lapping.

House Group

Culex pipiens, the common dark brown, rain barrel mosquito.
Culex territans (*Culex restuans*).

Salt Marsh Group

Aedes sollicitans (*Culex sollicitans*). White banded, salt marsh mosquito.
Aedes cantator (*Culex cantator*). Large brown, salt marsh mosquito.
Aedes taeniorhynchus (*Culex taeniorhynchus*). Small salt-marsh mosquito.
Culex salinarius. Brackish water, rather than salt water.

Fresh-Water Woodland Group

Aedes vexans (*Culex sylvestris*; *Aedes sylvestris*). Common marsh mosquito.
Aedes stimulans (*Culex stimulans*; *Culicida subcantanus*). Brown woodland mosquito.
Aedes canadensis (*Culex canadensis*). Woodland pool mosquito.
Mansonia pertrubans

Disease Carrying Group.

Aedes calopus (*Stegomyia fasciata*) transmits yellow fever; not found in Massachusetts.

Anopheles quadrimaculatus, transmits malaria.

Anopheles punctipennis, transmits malaria in the south but apparently not in the north.

Anopheles excrucians, transmits malaria, but infrequently.

Culex fatigans (*Culex quinquefasciatus*), transmits dengue or break-bone fever and filariasis; not found in Massachusetts.

The three worst pests of the Boston Metropolitan District are *Culex pipiens*, the house mosquito, *Aedes sollicitans*, the white banded salt-marsh mosquito, and *Aedes vexans*, the common marsh mosquito. Some of the others have been common this summer, such as *Aedes taeniorhynchus*, the small salt-marsh mosquito.

As to their habits, we find that *Culex pipiens* breeds in any water near houses, brood after brood, from the first warm days until cold weather. Eggs are laid in water. Adult females hibernate in cellars and buildings. Short flights. Enters houses.

Culex territans has similar habits, but prefers cleaner water and seldom enters houses.

Aedes sollicitans breeds very early (March) and continues through August or September. No regular succession of broods. Hibernates in egg stage and eggs will last more than one year. Often travels five miles and occasionally more.

Aedes cantator has similar habits. *Aedes taeniorhynchus* does not fly far inland. Both *Aedes salinarius* and *Aedes taeniorhynchus* prefer brackish waters.

Aedes vexans winters in the egg stage at the bottom of pools, breeds early and late, chiefly in temporary puddles, frequents porches and gardens, but seldom enters houses.

Aedes canadensis hibernates in the egg stage, hatches very early (March) and usually has but one brood a year.

Mansonia perturbans has larvae which do not go to the surface of water and which hibernate at the bottom of pools near the roots of sedges. There is but one brood a year.

Anopheles quadrimaculatus hibernates as adults in cellars and sheltered places, has successive broods, but a shorter season than *Culex pipiens*. Eager to enter houses.

Anopheles punctipennis is a short flyer, seldom found in dwellings but frequents stables, chicken-coops, and sheds.

Enough has been said, perhaps, to show that an entomological survey of the state should be made in order to give us more complete information as to the kinds of mosquitoes found and their relative abundance in different sections. The Anti-Mosquito Association of Massachusetts, through its Technical Committee, will doubtless give consideration to this matter. There ought to be a medical entomologist or a biologist learned in entomology attached to the staff of the State Department of Public Health. This department has already appointed a "Mosquito Board" from the membership of the Council and staff to study the mosquito problem and coöperate with the Association.

DRAINAGE.

We cannot appreciate the magnitude of the problem of mosquito control unless we learn the number, size, and location of the swamp areas, as well as the ponds and pools, in which mosquitoes breed. During the summer the city engineers of the Metropolitan area were asked to send to the association local maps showing roughly the location of existing swamp areas and wet lands. The data thus obtained have been put together on a map of the District. They indicate that the problem ahead of us is a large one. At present one can only guess at the mosquito breeding areas within ten miles of the State House, but it is probably more than 10 000 acres, — say 3 500 acres of salt marsh and 7 000 acres of land wet with fresh water. The different tracts vary all the way from a fraction of an acre to several square miles.

The engineer must play an important part in the work of mosquito control. If permanent results are to be secured, hundreds of acres of wet lands must be drained. In this state we have both salt marshes and inland marshes and they require different methods of treatment. Some of the land is privately owned, some of it belongs to cities and towns, and some to the

state. The swamp areas sometimes extend across boundary lines. Engineers ought to help in this problem because they have been in a measure responsible for existing conditions. For example, a roadway is built across a salt water creek; the water above the culvert backs up, holds the flood waters and gives opportunity for *Aedes salinarius* to breed. The railroad embankments built across the swamp areas northwest of Cambridge have created conditions favorable for mosquito breeding, and there are probably many other places where this is true. When the Charles River Basin was made and streets laid out near it in Cambridge, the low lying rectangular areas between the streets were not drained and millions of *Culex pipiens* were found breeding there in 1918. In the Charles River drainage area some of the dams are so high that the water floods vast areas, which breed mosquitoes. A reduction of the water level, if practicable, would do a world of good. I would like to see the city engineers of the various cities and towns in and near Boston brought together as a committee to suggest coöperative measures, and very likely the Anti-Mosquito Association will call upon them for advice. It might be even better for the Sanitary Section of the Boston Society of Civil Engineers to take the initiative in this matter.

In some ways the condition of the low lands near Boston is worse than in years gone by. Many areas were drained by the farmers for agricultural purposes, but when city developments drove out agriculture, the old ditches began to fill up, to cave in so that minnows and other little fish no longer swim up into them and devour mosquito larvae as they will do if given a chance. Urban conditions should be less productive of mosquitoes than rural conditions, but apparently the worst conditions of all obtain after the farmer has given up and before his farm has been fully converted into a city. As Dr. Drown used to say, with so much truth, "A state of change is a state of danger."

There are evidences, however, that drainage is again to be taken up in Massachusetts. It ought to be taken up. There is money in it; there is health in it. The state has many square miles of wet lands going to waste. Land cannot be sold by the gallon; drained swamps can be sold at a good price.

The state now has a Drainage Board (General Laws, Chap. 252, Sections 1 to 14A) composed of a member of the Department of Public Health and a member of the Department of Agriculture the function of which applies to a "meadow, swamp, marsh, beach or other low land held by several (more than two) proprietors" which it may be "necessary or useful to drain or flow" or to "remove obstructions in rivers or streams leading therefrom." On petition of the proprietors, or a majority in interest either in value or in area, the Drainage Board will make surveys, hold hearings, and, if thought advisable, authorize the formation of a local drainage district and appoint district commissioners. The commissioners are required to call a meeting of the proprietors and arrange for organizing a corporation to carry out the undertaking, if they vote to do so, under the ordinary state laws governing corporations, the proprietors being the members of the corporation, and no capital stock being required. The district drainage commissioners have charge of making the necessary improvements. The cost, which may be paid in the first instance by the county, if the county commissioners are petitioned and they so vote, is assessed on the lands benefitted through the town or towns in which such lands lie. If any part of the improvement is found by the Drainage Board to be for the benefit of the public health, the expense of that part is to be paid by the Commonwealth. After the improvements have been completed the district commissioners are retired and maintenance devolves upon the district corporation, which may assess its members. Several drainage districts are already organized or are being considered,—among them are Green Harbor, Salisbury, Weweantic (Carver), and Hering River (Wellfleet).

MALARIA IN MASSACHUSETTS.

Malaria is not now a common disease in Massachusetts. There have been periods, however, when it has appeared and some of the epidemics were serious. Even yellow fever was prevalent here in the early days. Accounts of these early epidemics may be found in Volume I of my book on State Sanitation. Malaria was made a reportable disease in this state in August 1914. Miss Hamblen, statistician of the State Department of Public

Health, has compiled the number of cases and deaths for the years 1915-1920. The total numbers of cases and deaths were as follows:

MALARIA STATISTICS.

Year.	Cases.	Deaths.
1915.....	112.....	6
1916.....	97.....	4
1917.....	78.....	5
1918.....	82.....	5
1919.....	72.....	4
1920.....	60.....	5
1921.....	49.....	2

Usually the number of cases has been less than 100 per year and the disease has occurred sporadically, first in one place, then another. The places in which more than ten cases of malaria have occurred in one year since 1914 are Boston, Fall River, Framingham, Newton, Dedham, Milford, Uxbridge. Between 5 and 10 cases in one year have occurred in Lynn, Natick, Wellesley, Douglas, and Northbridge. Reports of malaria were received from 76 cities and towns sometimes only a single case.

The facts show that while the malaria situation is not bad, as compared with states to the south, it is not as satisfactory as it ought to be. Massachusetts is within the upper limit of the southern mosquito zone and within the lower limit of the northern or Canadian zone. In other words, we are attacked both from the north and from the south. Anopheline mosquitoes are often found in the state. I found one only a short time ago at my house in Cambridge. Something else is necessary, however, to produce a malaria outbreak,—namely, persons in whose blood the malarial plasmodia are present. Such people are always liable to come here, either from the malarial regions of our own country or from other countries. Laborers from the pestilential marshes of southern Italy who were employed in digging the streets for a sewerage system spread malaria, and this gave rise to the now exploded theory that the disease was caused by a disturbance of the soil. Malaria is prevalent in many countries of Europe from which we have received immigration. I have been in certain parts of Roumania, near the marshes of the

Danube, where almost the entire population had or once had had the disease. Such malaria laden immigrants, coupled with the anopheles mosquito, are a menace to the public health. The proper remedy for this situation is quinine for the sick people, and oil or drainage for the mosquitoes.

We have not as yet, so far as I know, had dengue fever in this state. In the Gulf States it is now quite prevalent, and at times the disease is met with further north. Perhaps it may some time come here. Yellow fever has been here.

The hopeful thing about the situation is that these mosquito-borne diseases can be controlled, and at an expense well within the means of the people. The spectacular success of Gorgas and others at Havana, Panama, and in South America is being repeated in many places in the South and West, thanks to the well sustained work of the Rockefeller Foundation and the United States Public Health Service. It is being repeated in many foreign countries, thanks to the International Health Board and to the efforts of their own health departments. The State of Florida has done excellent work in the suppression of malaria and dengue fever, Mr. George W. Simons, the State Sanitary Engineer, being a leader. New Jersey has for many years carried on an active and, on the whole, a very successful campaign against the mosquito. The City of Providence and our town of Brookline have long waged an effective campaign, and many other places near at home might be named where suppressive measures have been carried on for a longer or shorter time.

SUMMARY.

The Anti-Mosquito Association of Massachusetts has not yet announced its policy, but in the opinion of its president the following lines of endeavor must be followed.

1. An entomological survey of the state to determine what kinds of mosquitoes are found and when and where the different species are prevalent.
2. A sanitary survey to determine the location of the wet lands and the best methods of draining them.
3. The organization of local mosquito committees, each with a local staff in charge of a field director, co-operating with

the association, and with the territory subdivided again and again, in order that all parts may be inspected at frequent intervals by interested citizens.

4. The collection of local funds by local committees for local use in the actual work of suppression.

5. The use of the police power, if necessary, by the local health boards to secure the abolition of mosquito breeding conditions.

6. The collection by voluntary subscription of a small fund needed for the work of the association.

7. The appropriation of money by local governments for oiling and for any appropriate suppressive measures to be applied to public lands, such as streets, catch-basins and parks.

8. The appropriation by the state of money needed for suppressive measures in state lands (including the Boston Metropolitan District) expenditure to be made by the Metropolitan District Commissioner.

9. The appropriation by the State, of money necessary to provide the State Department of Public Health with a medical entomologist.

10. Persistent propaganda by the association until proper coöperation between the people, the local governments and the state government has been assured.

11. A general understanding that the above measures should be pursued actively for two or three years with the expectation that if the measures succeed in reducing the mosquito nuisance efforts should be made to have the work carried on by the governmental authorities rather than by a voluntary association.

The suppression of mosquitoes more than that of most nuisances lies in the hands of the people themselves. The remedy is easy but complex. It will require the doing of many trivial things, such as picking up an old tin can, or examining the gutter of a house. There is danger of starting off vigorously and then lapsing into carelessness. There is danger lest the people be "too proud to fight." Massachusetts can get rid of her mosquito nuisance if the people are willing to take the trouble and pay the price.

DISCUSSION.

C. T. BRUES.*—I have been very much interested to note the list of mosquitoes which Professor Whipple mentioned, as they were just about the same ones I had selected. It may seem to you queer we should have selected the same ones. As a matter of fact there are in this vicinity about 20 to 30 species, but those which are actually annoying can be reduced to 8 or 9, including the two malaria carrying mosquitoes, which are really numerous or dangerous. Suppose we consider these various species in three groups, as Professor Whipple suggested.

First, the *Salt Marsh* species. In Massachusetts there are only three, though further south there are quite a number.

Culex Sollicitans, which breeds in salt water and lays its eggs ordinarily just at the edge of the water. As the salt marsh dries up between the high tides the eggs become dry and ordinarily don't hatch until the succeeding year which means that the great majority hatch in June and the *Sollicitans* becomes abundant in that month and lasts for some time afterward, because at various high tides later in the season the eggs which don't hatch at first will hatch. So there is a big brood in June and then smaller broods for several weeks later. They last practically through the whole season.

Aedes Cantator, also breeds in salt marshes under practically the same conditions as *Sollicitans*, and it is not an easy matter to tell them apart.

Culex Salinarius, breeds usually rather close to the other two, but is found most commonly in water which is almost fresh. The name *Salinarius* was given to it because it almost always occurs in salt marshes or nearby, but is always restricted to water pretty nearly fresh.

To distinguish the three kinds, the *Sollicitans* is very easily recognized. If we look carefully we find a head with large eyes each side (illustrates the following descriptions on black-board) and a proboscis sticks out in front. On the side here are very delicate feathered feelers—*antennae*. In the male they are heavily feathered, but not in the female. It is the female that we ordinarily notice. The male keeps out of the way.

*Professor Department of Economic Entomology, Bussey Institute, Harvard University.

The head is attached to the body by the thorax, and the abdomen behind is composed of a number of pieces, though it appears as one large piece. The legs are attached to the thorax and there are three pairs. As you know, the legs of the mosquito are long, composed of a number of joints terminating with a little pair of claws. Around the proboscis there is a white band. The leg joints — these little tips here — are also surrounded with white bands. On the side of the thorax is a brilliant silvery mark. Also on the abdomen there are buff bands. It is something like the yellow fever mosquito.

Cantator has not these white marks. The thorax is covered with bristles — brownish hairs. These mosquitoes migrate some distance. In New Jersey I have known them to travel for miles. Here, not quite so far.

Sollicitans I have seen in Forest Hills some miles from its breeding ground.

Salinarius doesn't go far. *Salinarius* looks very much like the two next ones — the house mosquitoes.

HOUSE SPECIES

Culex Pipiens.—Most of the house mosquitoes are of European origin, introduced into the United States, and like all European pests are very abundant and annoying.

Culex Territans.—Is very similar in habits and appearance. So we have these three looking very much alike. *Salinarius* breeds near salt marshes and is particularly common in summer resorts as along the South and North Shores.

Pipiens we find practically everywhere, breeding in dirty water. Most mosquitoes like clean water, but *Pipiens* prefer dirty water with a good deal of odor and a large amount of decaying organic matter. *Territans* is similar but prefers cleaner water.

Those three species have no band on the proboscis. They have bands on the taussí, which however are very inconspicuous, and the abdominal marks are much fainter. Rather nondescript mosquitoes are apt to be these.

Salinarius is found along the coast and the larvae of those one looks for on the edge of salt marshes. I have noticed frequently the presence of *Salinarius* due to the building of a road where some of the salt marsh has been cut off from the ocean and has resulted in the water on that side becoming fresher than when the tide had access. And these other two occur further back from the coast practically everywhere.

Now in addition to the house species we might perhaps include two species of *Anopheles*. There are various species of *Anopheles* throughout the world and they carry malarial fever of various kinds. We have here two species. One is the *Anopheles Punctipennis*, which is rather common and does not carry malaria in the north, so far as we know. And there is one which cannot be distinguished from it which carries Tertian malaria in the South. We never find malaria in Massachusetts where only the *Punctipennis* is present. *Anopheles Quadrimaculatus* is the one we commonly have here. In the *Anophelines* the structure of the body is quite different. They are very easily recognized. The females have a beak and on either side a short pair of appendages between the feelers and the beak. These are the palpi. They are very short — almost indistinguishable — in other mosquitoes, but in the *Anophelines* they are long. The males don't come close to people. They keep out of the way. So there are three things sticking out at the head, instead of a single projection as in the other forms. The two kinds of *Anopheles* can be distinguished, but not readily.

The wing of a mosquito is quite narrow and rather long. It is attached at the thorax. All of these other forms have the wings, with a number of veins as you know, which are covered with minute scales of a brownish or dark color, so that the wings are not transparent but are uniform in appearance. In all *Anophelines* there are spots which extend beyond the dark scales on the veins. The *Anopheles Quadrimaculatus* has four dark spots and practically no light spots. The *Punctipennis* spotting is more regular and most noticeable for two dark and two lighter spots along each of the wings. Any spotted wing mosquito in Massachusetts is an *Anopheles*. The smaller form, *Quadrimaculatus* has only four distinct dark spots and no light spots and

this is the one to look out for as it actually carried malaria. The markings on the legs,— the bands — are not so very conspicuous. The best way to distinguish them is by the wings. Those are the ones which ordinarily bother us in the house and on the beach and piazza, in the yard, etc.

On farms and in woodlands there are other forms, a few of which Prof. Whipple has mentioned — the same which I had thought most common from my own experience.

First, *Aedes Silvestris*, or *Canadensis*. There are a good many others and it is rather hard to pick out the most abundant. Everyone knows certain places where one species is more common than the others. Right around Boston there are six or eight species which seem to be numerous enough to be annoying although usually one or the other of these two are present. *Canadensis* appears earlier in the season, and more or less disappears later. It over-winters in the egg stage, goes through larvae development and becomes fully developed when the marshes are flooded, which results in a rapid development of the larvae when the eggs become wet in the spring.

Sylvestris broods follow one another and the species becomes more common in the late summer. They, too, select places where there is water. Consequently we find them in areas where we think it is quite dry, because the mosquitoes have had their brood there earlier when the place was flooded. One of the best indications if you are not present when the mosquitoes are breeding is a study of the vegetation, as an index as to where to find the mosquitoes. In many of these places if, for example, we could examine the vegetation later in the season after some of these areas have dried up, it is practicable by the grasses and sedges to get an index of where the mosquitoes came from. I am afraid I have not given a very clear account of the species, but as a matter of fact some of them it is almost impossible to distinguish without a rather powerful hand lense, and there are so many of them it is ordinarily most convenient to refer to a key of some kind.

If I could have a moment more I would like to say just a word about the larvae.

They are extremely interesting. I prefer collecting them and identifying them rather than the mosquito. The character is more easily seen. They live in water, having a projective breathing tube. The body hangs down in the water and the head is at the bottom, so we have this siphon at the posterior end sticking through the water and getting air for the mosquito to breathe. This siphon is sometimes very long. In the *Culex Pipiens* it is very long and narrow, and in most *Aedes* it is very short and perhaps somewhat swollen in the center, like this (illustrates). In the *Culex* there is a little series of bristles here (illustrates). *Salinarius*, *Pipiens*, *Territans*, *Restinans* are very similar in these characteristics. *Aedes* have a series of comb like bristles at the base of the tube, and *Aedes* and *Culex* are distinguished readily, only in the larvae stage, by a brush of bristles and the short stiff bristle. The *Anopheles* breathing tube is very short and consequently the body lies more or less flat on the water, with the head close to the surface and the stellate hairs come out about half way down on the body and help keep the larva on the surface. The *Anophelines* rest near the surface and the *Culex* hang down.

The pupae remain at the surface of the water if they are not disturbed. They are of rather peculiar shape with head, thorax and abdomen rather small and a pair of horns projecting from the middle part of the body for air. The larvae are commonly seen wiggling around in the water. If the water is disturbed they usually go to the bottom and hide in the mud or dirt. They will hide for a while and then come to the surface again and thrust their tubes through to breathe.

If anyone has any question I will be glad to answer them. I don't know so very much about the mosquitoes around Boston, because I have not studied them except in a few areas particularly north of Boston and around Dedham. Professor Brues in reply to questions continued:

In the ordinary summer temperature I think the average length of a generation of the mosquito might be about three weeks. That is to say, it would be less from the egg to the adult, but it is necessary for the adult after it hatches to remain a few days in the feed before the eggs mature. Ordinarily a generation

develops in ten days and probably it is another week or ten days before another brood is produced, so the number of broods is not so great as might be supposed. In cooler weather they grow more slowly. In the spring and fall they grow very slowly. The growth corresponds to variation in temperature.

The range of temperature under which they develop varies with the different forms. Some come out early in the spring. Some breed in melting snow in very cold weather. Many appear in March and April. They are quite common the latter part of April. *Anopheles* develops very slowly in the early part of the season, and hardly comes here until September. There is only one noticeable brood of those. They come in the rather late summer.

Mosquitoes breed in catch basins, in fact catch basins have been devised to contain a film of oil to prevent mosquitoes breeding. By a *siphonic* arrangement by which the water is drawn off at the bottom, a film of oil is kept all the time on the surface of the water. It is quite an annoying feature in many cities, the catch basin breeding spots.

The oil is just poured in, or preferably sprayed. Preferably, a very light oil is used because it is not carried down so readily with the water and comes more quickly to the surface. Kerosene is usually preferred.

As to what the mosquitoes feed on in the woods where there are no people, that is a very puzzling thing because commonly the mosquito cannot fertilize her eggs without blood. We think they must get it from birds, probably mostly at night when they are roosting. Possibly also from reptiles, but mainly from birds. I wouldn't dare to say so before the Audubon Society, because it seems rather radical to get rid of the birds in order to get rid of mosquitoes. They undoubtedly do get a good deal of blood from birds.

If the salt marshes were drained and minnows let in that would be very effective, especially the top-minnow. Where there is a pool with those minnows there are no mosquitoes and no pupae. They don't get the larvae so well, but of course if they get the pupae it is the same thing. I have often found larvae but not the pupae. That is one of the most efficient natural

means of controlling mosquitoes. In fresh water gold fish are used as they are very fond of mosquito larvae. In the tropics in many places it is possible to keep the larvae under control by means of gold fish.

The question is asked as to whether the organism of malaria and yellow fever can be carried in the bodies of birds and other warm blooded animals?

Yellow fever is peculiar to the human species, although it has recently been said it could be transmitted to apes. Also supposed organisms can be recovered from animals like guinea pigs, though they show no symptoms except a slight rise in temperature. Only one type of mosquito carries yellow fever. In the case of malaria there are several species of *anopheles* — some carry one kind and some another. Some carry the disease much more rapidly than others, as it is necessary to develop the organisms in cysts in the stomach. So there is a very considerable variation. Mosquitoes never carry the malarial organisms over the winter, however. They are never infectious in the spring, but only from chronic cases of malaria. That is why we have malaria common in the southern states and even in the central parts of the United States when we don't have yellow fever, because it dies out as there are no chronic cases of yellow fever but it has to be brought in and comes in the form of epidemics.

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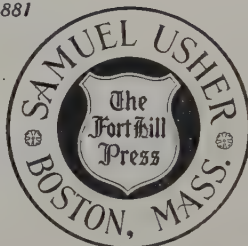
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